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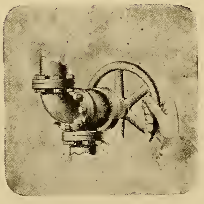

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TO

CASSIER'S MAGAZINE.

VOLUME III.

Thomas A. Edison.

CASSIER'S MAGAZINE.

VOL. III. NOVEMBER, 1892. NO. 13.

THE LIFE AND INVENTIONS OF EDISON.

By A. and W. K. L. Dickson.

First Paper.

THE present century is pre-eminently one of daring and potential intelligence. The new age, with its clearer thought, its wider scope of action, and its humane and liberal institutions, has proved itself an excellent foster mother for nascent ideas, and countless inventions, which, under mediæval auspices, must have been stifled at birth, as direct emanations from the evil one, have been nursed into being, and have attained a stature in keeping with the grandeur and breadth of perfecting humanity.

Released from the swaddling clothes of error and superstition, the inherent virility of man has reasserted itself, and to the untrammeled vision and ripened energies of the scientist, the arcana of nature have been gradually disclosed. Foremost amongst these has been the discovery of that most magical and mysterious potency, the electrical fluid. The prosecution of this comparatively crude and untried science was at first attended by laborious thought and imperfect results, and little progress was discerned until within the past half century, when the eyes of the scientific world were opened to the vast resources and limitless adaptability of the new fields of thought.

Amid these improved mental conditions Thomas Alva Edison was born, and whilst it will be seen that his early career was attended by many painful hardships, his life, on the whole, may be considered a felicitous one, presenting, as it does, the spectacle of a man abreast with the times, and in touch with the progressive thought of the day.

Little is known regarding the remote ancestry of our hero, beyond the fact that his family was of Dutch origin, and emigrated to America in 1730, where the grandfather of Samuel Edison attained an enviable celebrity as banker on Manhattan Island during the Revolution. There is reason to believe that the roll call might be extended back indefinitely, and fraught with the most interesting and creditable details, but the good-natured indifference of its most distinguished descendant has proven an insuperable bar to research. I pinned him down recently—a feat about as difficult as the domestication of an electric eel, and besought him, in view of our long and affectionate intercourse and by all the ties which bound him to an adoring public, to supplement the meagre information regarding his forefathers. In vain. Edison merely flashed upon me his own peculiarly luminous smile and replied like the "gray-haired schoolboy" that he will ever be—"Oh! let up, Dickson, why, what in thunder can I say about them?

Well! let's see. They were millers on the Zuyder Zee way back. My great-great-grandfather was born in Amsterdam, and the rest of the family, I guess, were all right"—with which exhaustive family pedigree I was forced to be content.

Thomas Alva Edison was born on the 11th of February, 1847, at Milan, Erie County, Ohio. His father, Samuel Edison, who, at the advanced age of 88, still retains his remarkable mental and bodily powers, was and is a man of sterling business abilities. His wife, Nancy Elliot, was a native of Chenango County, a Canadian by residence and education, and a Scotchwoman by parentage. It will be seen, therefore, that the two national streams which have been most potential in determining the currents of the world's history—the Teutonic and the Celtic — met in the veins of our hero. Mrs. Edison was a woman of sweet and strong individuality, equipped with a solid, if unpretentious, education, acquired in the Canadian high schools, and endowed with rare abilities as a teacher. She was eminently qualified to deal with the plastic mind of her son, and it was to her judicious efforts rather than to those of his father, that Edison owed that early impetus which gave such admirable scope and direction to his dawning powers.

THOS. A. EDISON AT FOUR YEARS OF AGE.

There is a widely-spread notion abroad that Edison is a rough and uncultivated man, devoid of early training, and educated simply from a business or scientific standpoint. Nothing could be more erroneous. Edison is a self-made and self-educated man, it is true, but for that very reason, his attainments are substantial and based upon an inherent love of study. Callow collegians, dragged through an uncongenial course of study, boarding-house graduates, "steeped in a weak solution of accomplishments," ephemeral creatures, on whose glossy plumage the dews of Parnassus have no power to rest—these have formed themselves into a tribunal of final appeal and their dictum has been accepted by the world at large. But the true facts are, that Edison, outside of the inventive vein by which he is exclusively known, possesses a mind virile, original and stored with varied and extensive information. At the age of twelve, a period when most boys are inflaming their imagination and perverting their moral sense with trashy and sensational fiction, Edison, partly from inclination, partly from over conscientiousness, was wading through such ponderous tomes as Burton's "*Anatomy of Melancholy*," Gibbon's "*Decline and Fall of the Roman Empire*," Hume's "*History of England*" and "*History of the Reformation*," Ure's "*Dictionary of the Sciences*," the *Penny Encyclopedia* and "*Newton's Principia*." The latter work proved somewhat above his mental capacity, and had his lot been cast some two centuries earlier, he would probably have endorsed the attitude of the Newtonian audiences, who, on the tes-

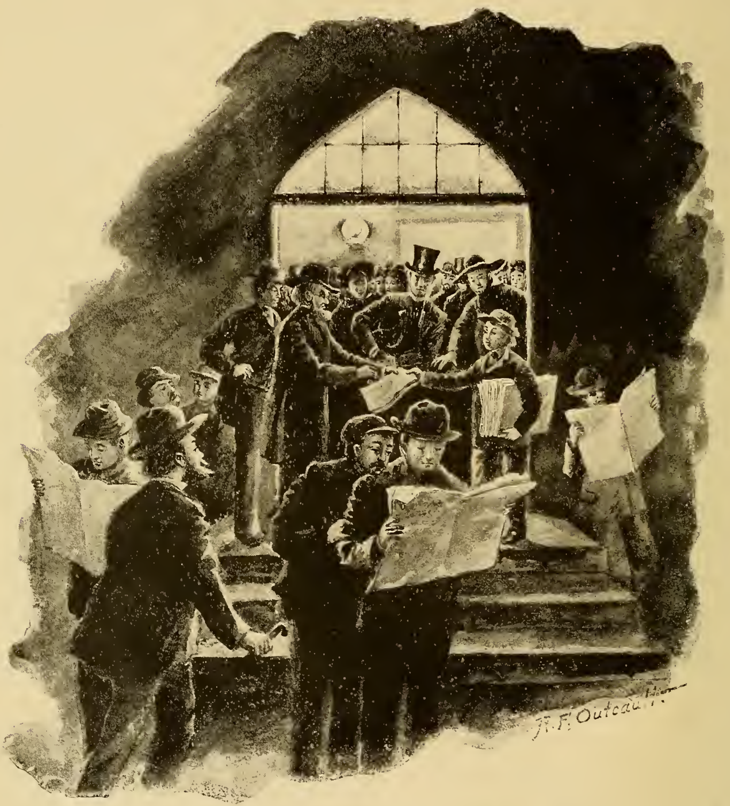
timony of the philosopher's amanuensis, went to his lectures in such small numbers and betrayed so little comprehension of him, that "oft times he did in a manner for want of hearers read to the walls."

Mystified by the obscure and technical language of the "Principia," Edison resorted to outside assistance, and received from the lips of a comparatively uneducated man such a simple and satisfactory explanation as to confirm him in his intolerance of mathematics as a basis for scientific instruction. "This man," says Edison, "explained the problem to me by the use of very simple language and without the employment of mathematics. I at once came to the conclusion that Newton could have dispensed his knowledge in a much wider field had he known less about figures. It gave me a distaste for mathematics from which I have never recovered. If I were asked to explain the phonograph to one unfamiliar with it, I would not display all the tools and machinery which are used in making the instrument. I look upon figures as mathematical tools which are employed to carve out the logical result of reasoning, but I do not consider them necessary to assist one to an intelligent understanding of this result."

Edison's literary proclivities were seriously hampered by the collapse of the family fortunes, and the early necessity of gaining his own living. A reduction of tariff on the Milan canal, owing to the construction of the Lake Shore Railroad, caused a wide-spread depression in commercial affairs, and so seriously undermined the social standing of Samuel Edison, as to force him to leave his picturesque home, and begin his life anew in the town of Port Huron, Michigan. This transpired in the year 1854, when Edison was only seven years old. Despite his paucity of years and the prac-

THE BIRTHPLACE OF THOMAS A. EDISON.

tical claims which life had already imposed, Edison devoted every spare moment to the improvement of his mind, and profited to the utmost by the wise and gentle tuition of his mother. We suspect that his thirst for knowledge needed restraint rather than encouragement, it we may judge by the tact that he actually attempted to read through the entire Free Library at Detroit, and that he completed fifteen feet of closely serried volumes before his excessive ardor could be discovered and curbed.



"IN TWO MINUTES THE PRAYER MEETING WAS ADJOURNED." [SEE PAGE 7.]

Physically and mentally, this extraordinary youth seemed incapable of fatigue. To his teeming energies and prolific brain, rest and action were synonymous with stagnation, and his faculties only derived fresh lustre and vigor from his ceaseless round of toil. His next enterprise was as daring as it was original. It was in April of the year 1862. The hostilities between the North and South were at their height, and the press teemed with exciting details, of which the battle of Pittsburg Landing,

with its fifty thousand killed and wounded, formed an important item. Edison brought his winning ways to bear on the operators, controlling the line, and by the tempting offer of a daily paper and two or three monthly magazines, obtained the use of the official blackboard for the publication of bulletins or headlines in advance of the expected trains and their literary freight. His next move was to cajole the editor of the Detroit *Free Press*, Mr. William F. Story, out of a thousand copies of the paper, to be paid from the proceeds of the venture, and to induce the locomotive engineer to allow him a few minutes' grace at the various stopping places. Edison thus describes his triumphant progress: "At Utica, the first station out from Detroit, and about twelve miles distant, I usually sold two papers, our customary charge being five cents each. As we approached the station on this day, I put my head out to look forward, and thought I saw an excursion party. I had a half dozen papers in my hand. As we came nearer, and the people caught sight of me, they commenced to gesticulate and shout, and it suddenly occurred to me that they wanted papers. I rushed back into the car, grabbed an armful, and when I got upon the platform I sold forty. Mount Clement was the next station. When it came in sight I thought there was a riot. The platform was crowded with a howling mob, and when the tones became intelligible, I realized that they were after news of Pittsburg Landing, so I raised the price of papers to ten cents and sold a hundred and fifty where I had never before disposed of more than a dozen. As other stations were reached, these scenes were repeated, but the climax came when we got to Port Huron. The station there was a mile from the town. When the train stopped I shouldered my bundle and started for the city. When I had got less than half way I met a crowd hurrying toward the station. I thought I knew what they were after, so I stopped in front of a church, where a prayer-meeting was being held, raised

THOMAS A. EDISON AT FOURTEEN YEARS OF AGE.

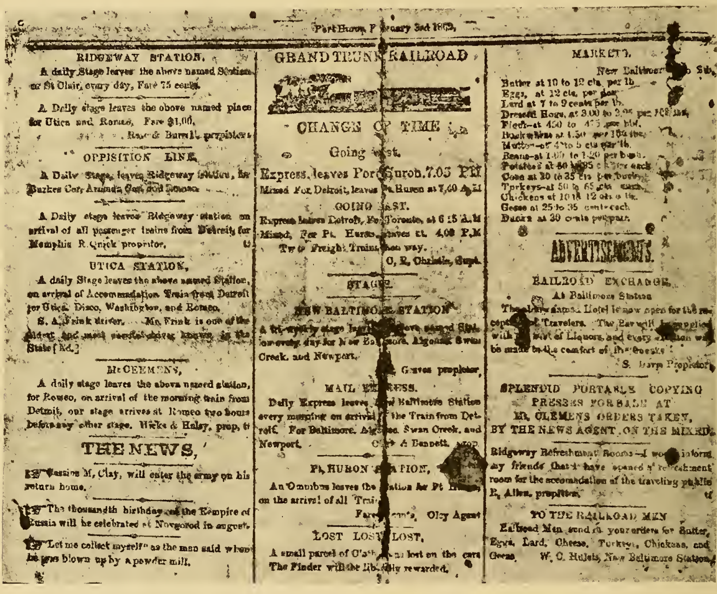
the price to twenty-five cents per copy, and commenced to take in a young fortune. In two minutes the prayer-meeting was adjourned, the members came rushing out, and if the way coin was produced is any indication, I should say that the deacons hadn't passed the plate before I came along."

This successful enterprise emboldened him to start a paper under independent auspices, and in the spring of the same year (1862) he purchased a disused lot of old type and stereos, formerly in the possession of the Detroit *Free Press;* fitted up a dilapidated freight car as

workshop and editorial sanctum, and burst upon the migratory world which flitted up and down the lines of travel with the *Grand Trunk Herald*, the first and last sheet ever published on a train. The novelty of the idea worked like a charm, and speedily sent the circulation up to four hundred, enlisting the good will of Stephenson, the famous engineer, and eliciting a cordial tribute of admiration from the London *Times*.

hands of a stalwart and indignant subscriber.

Misfortunes, like birds, flock together, and the same year which witnessed the ignoble extinction of *Paul Pry*, saw the collapse of Edison's nomadic laboratory. The car in which his experiments were carried on was destitute of springs, and like the "one hoss shay of immortal memory," was in a complete and consistent state of decay. The constant



Port Huron, February 3rd 1862,

RIDGEWAY STATION.

A daily Stage leaves the above named Station for St Clair, every day, Fare 75 cents.

A Daily stage leaves the above named place for Utica and Romeo, Fare $1,00.

Rose & Burrell, proprietors

OPPISITION LINE.

A Daily Stage, leaves Ridgeway Station, for Burkes Cor, Armada Cor, and Romeo.

A Daily stage leaves Ridgeway station on arrival of all passenger trains from Detroit for Memphis R. Quick proprietor.

UTICA STATION,

A daily Stage leaves the above named Station, on arrival of Accommodation Train from Detroit for Utica, Disco, Washington, and Romeo.

S. A. Frink driver. Mr. Frink is one of the oldest and most careful driver known in the State [Ed.]

Mt CLEMENS,

A daily stage leaves the above named station, for Romeo, on arrival of the morning train from Detroit, our stage arrives at Romeo two hours before any other stage. Hicks & Haley, prop.

THE NEWS,

Cassius M. Clay, will enter the army on his return home.

The thousandth birthday of the Empire of Russia will be celebrated at Novgorod in august.

Let me collect myself" as the man said when he was blown up by a powder mill.

GRAND TRUNK RAILROAD

CHANGE OF TIME

Going west.

Express, leaves Port Huron 7.05 PM

Mixed For Detroit, leaves Pt. Huron at 7,40 A.M

GOING EAST.

Express leaves Detroit, For Toronto, at 6 15 A.M

Mixed, For Pt. Huron, leaves at 4,00 P.M

Two Freight Trains each way.

C. R. Christie, Supt.

STAGES.

NEW BALTIMORE STATION

A tri-weekly stage leaves the above named Station every day for New Baltimore, Algonac, Swan Creek, and Newport.

Graves proprietor,

MAIL EXPRESS.

Daily Express leaves New Baltimore Station every morning on arrival of the Train from Detroit. For Baltimore, Algonac, Swan Creek, and Newport.

C. A. Bennett, prop.

Pt. HURON STATION,

An Omnibus leaves the Station for Pt. Huron on the arrival of all Trains.

Fare cents, Olny Agent

LOST LOST LOST,

A small parcel of O's was lost on the cars The Finder will be liberally rewarded.

MARKETS.

New Baltimore Sth,

Butter at 10 to 12 cts. per lb.

Eggs, at 12 cts. per doz.

Lard at 7 to 9 cents per lb.

Dressed Hogs, at 3.00 to 3.25 per 100 lbs.

Flour at 450 to 475 per bbl.

Buckwheat at 1.50 per 100 lbs.

Mutton at 4 to 5 cts per lb.

Beans at 1.00 to 1.20 per bush.

Potatoes at 30 to 35 cts per each

Corn at 30 to 35 cts per bushel

Turkeys at 50 to 65 cts each

Chickens at 10 to 12 cts a lb.

Geese at 25 to 35 cents each

Ducks at 30 cents per pair.

ADVERTISEMENTS.

RAILROAD EXCHANGE.

At Baltimore Station

The above named Hotel is now open for the reception of Travelers. The Bar will be supplied with the best of Liquors, and every attention will be made to the comfort of the Guests.

S. Harp Proprietor,

SPLENDID PORTABLE COPYING PRESSES FOR SALE AT

Mt. CLEMENS ORDERS TAKEN, BY THE NEWS AGENT ON THE MIXED.

Ridgeway Refreshment Rooms—I would inform my friends that I have opened a refreshment room for the accomodation of the traveling public

R. Allen, proprietor,

TO THE RAILROAD MEN

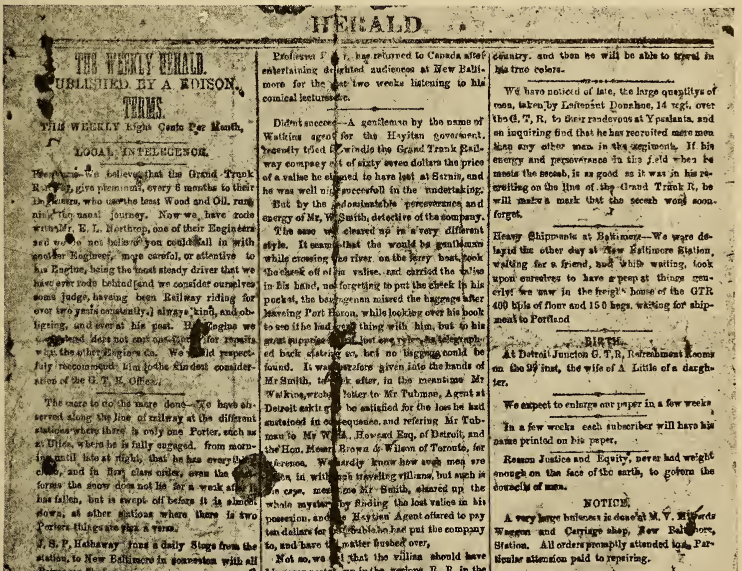
Railroad Men send in your orders for Butter, Eggs, Lard, Cheese, Turkeys, Chickens, and Geese, W. C. Hulets, New Baltimore Station,

FAC-SIMILE OF GRAND TRUNK HERALD—EDISON'S FIRST ENTERPRISE.

Encouraged by the success of his maiden effort, Edison extended his venture, and in conjunction with the "devil" of the *Port Huron Commercial*, started a sheet by the title of *Paul Pry*. This paper was mentally and mechanically superior to its predecessor, but unfortunately a boyish love of fun led the partners to indulge in a style of personality displeasing to the public, and the organ died with the immersion of the editor-in-chief in St. Clair River, at the

jolting dislodged the cork of a phosphorous bottle, hurling it violently to the ground and setting fire to the car. The flames were extinguished without much difficulty, but the wrath of the conductor was less easily allayed. For many months past that gentleman's olfactories had been assailed by horrible scents and his auditory nerves invaded by alarming reports. He was therefore inclined to view Edison in the light of an unmitigated nuisance rather than in

that of an interesting and incipient genius. The present crowning outrage gave him the revenge his soul had thirsted for so long, and in the twinkling of an eye our luckless hero found himself on the platform with his household goods raining about his ears. The episode has served as a basis for innumerable comic sketches, literary and artistic, but to our minds the pathos of the situation has never been sufficiently recog-



HERALD.

THE WEEKLY HERALD.
[illegible]UBLISHED BY A. EDISON.
TERMS.
THE WEEKLY Eight Cents Per Month,

LOCAL INTELLIGENCE.

[illegible]—We believe that the Grand Trunk R[illegible], give premiums, every 6 months to their [illegible], who use the least Wood and Oil. running the usual journey. Now we have rode with Mr. E. L. Northrop, one of their Engineers and we do not believe you could fall in with another Engineer, more careful, or attentive to his Engine, being the most steady driver that we have ever rode behind [and we consider ourselves some judge, haveing been Railway riding for over two years constantly.] always kind, and obligeing, and ever at his post. H[illegible] Engine we [illegible] dont not cost one [illegible] for repairs [illegible] the other Engines do. We would respectfuly recommend him to the kindest consideration of the G. T. R. Officers.

The more to do the more done.—We have observed along the line of railway at the different stations where there is only one Porter, such as at Utica, where he is fully engaged, from morning until late at night, that he has everyth[illegible] c[illegible], and in first class order, even the [illegible] forms the snow does not lie for a week af[illegible] has fallen, but is swept off before it is almo[illegible] down, at other stations where there is two Porters things are [illegible] a versa.

J. S. P. Hathaway runs a daily Stage from the station, to New Baltimore in connection with all Passenger Trains.

Professor F[illegible] has returned to Canada after entertaining delighted audiences at New Baltimore for the [illegible] two weeks listening to his comical lectures &c.

Didn't succeed.—A gentleman by the name of Watkins agent for the Hayitan government, recently tried to swindle the Grand Trunk Railway company out of sixty seven dollars the price of a valise he claimed to have lost at Sarnia, and he was well nigh successfull in the undertaking. But by the indominatable perseverance and energy of Mr. W. Smith, detective of the company. The case was cleared up in a very different style. It seams that the would be gentleman while crossing the river on the ferry boat, took the check off of his valise, and carried the valise in his hand, not forgetting to put the check in his pocket, the baggageman missed the baggage after leaveing Port Huron, while looking over his book to see if he had every thing with him, but to his great supprise [illegible] lost one, [illegible] he telegraphed back stating so, but no baggage could be found. It was therefore given into the hands of Mr Smith, to look after, in the meantime Mr Watkins wrote [illegible] letter to Mr Tubman, Agent at Detroit asking [illegible] be satisfied for the loss he had sustained in consequence, and refering Mr Tubman to Mr W[illegible], Howard Esq. of Detroit, and the Hon. Messrs Brown & Wilson of Toronto, for reference. We hardly know how such men are [illegible] in with such traveling villians, but such is the case, meantime Mr Smith, cleared up the whole mystery by finding the lost valise in his possesion, and the Haytien Agent offered to pay ten dollars for the trouble he has put the company to, and have the matter hushed over.

Not so, we [illegible] that the villian should have his name posted up in the various R. R. in the country, and then he will be able to travel in his true colors.

We have noticed of late, the large quantitys of men, taken by Leftenant Donahue, 14 regt, over the G. T. R. to their randevous at Ypsalanta, and on inquiring find that he has recruited more men than any other man in the regiment. If his energy and perseverance in the field when he meets the secesh, is as good as it was in his recruiting on the line of the Grand Trunk R, he will make a mark that the secesh wont soon forget.

Heavy Shipments at Baltimore.—We were delayed the other day at New Baltimore Station, waiting for a friend, and while waiting, took upon ourselves to have a peep at things generly. We saw in the freight house of the GTR 400 bbls of flour and 150 hogs. waiting for shipment to Portland.

BIRTH.

At Detroit Juncton G. T. R. Refreshment Rooms on the 29 inst, the wife of A. Little of a daughter.

We expect to enlarge our paper in a few weeks.

In a few weeks each subscriber will have his name printed on his paper.

Reason Justice and Equity, never had weight enough on the face of the earth, to govern the councils of men.

NOTICE.

A very large buisness is done at M. V. H[illegible]rds Waggon and Carriage shop, New Baltimore, Station. All orders promptly attended to. Particular attension paid to repairing.

FAC-SIMILE OF THE GRAND TRUNK HERALD—EDISON'S FIRST ENTERPRISE.

nized. Edison's local attachments were strong and his thirst for knowledge boundless. The battered car, with its primitive equipments, was dearer to him than the faultless laboratory of the successful scientist, and its sudden dissolution was a terrible shock. In all the sorrowful vicissitudes of Edison's life, and they were many, nothing more desolate can be imagined than the figure of this ill-clad, ill-fed boy, standing irresolutely on the deserted road, the fragments of his cherished possessions around him, and in the gradually lessening distance the outlines of his beloved workshop and sanctum. Nothing in his subsequent career illustrates with greater force the indomitable nature of the man than his philosophic acceptance of the situation, and his prompt re-installation of himself and belongings in the cellar of his father's house at Port Huron. Edison's experiments in telegraphy had inspired him with the desire of mastering the art completely, but his lack of funds and influence threw him almost entirely on his own resources. His new laboratory, located in the cellar of his father's house at Port Huron, had been fitted up with such fragments as had survived the writ of ejectment from the Grand Trunk line, and a work on telegraphy was

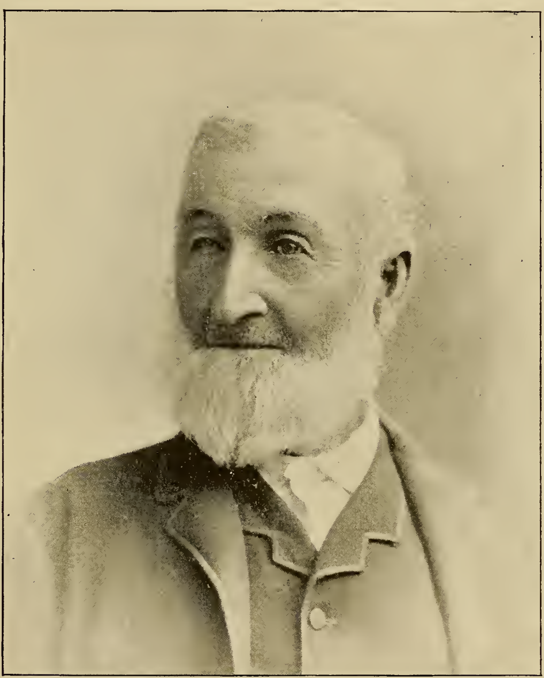
purchased, which he studied diligently night and day. His earliest experiments, made in conjunction with his friend James Ward, were primitive in the extreme, and brought the most crude materials into requisition. A line was constructed between the boys' homes, consisting of an ordinary stovepipe wire, insulated with bottles, and crossed under a busy thoroughfare by means of an old cable rescued from the bed of the Detroit River. The first magnets were wound with wire, swathed in ancient rags, and a piece of spring brass formed the key. With a view to generating a current and with a mind somewhat hazy on the score of static and dynamic electricity, Edison secured two Brobdingnaggian cats, with volcanic tempers, attached a wire to their legs, administered a violent amount of friction to their backs, and breathlessly awaited developments. Sad to relate, these zealous efforts ended in failure. The feline mind, concentrated on personal grievances, refused to lend itself to the pursuit of science, and the test resulted in a frantic stampede, enlivened by whoops and splutters. But as Mr. Reid, in his memorial volume, remarks, "The experiment was not without success; a tremendous local current and perfect electric arc were produced, but it would not work the line and was abandoned. The experiment illustrated the humor of the man." "This incident," says his associate of many years, Mr. Edward H. Johnson, "is perfectly

MRS. NANCY EDISON, EDISON'S MOTHER.

characteristic of the man. He will to-day undertake elaborate experiments and conduct them with great care and marvelous patience and perseverance, although his reason points to their utter futility. It is this trait, however, which led him into lines of original discovery and observation unattended by others."

Undismayed by these early failures, Edison steadily pursued his investigations, and by denying himself everything but the barest necessities of life, found means to invest in a number of old instruments and other materials. Fortune favors the brave—in that lady's rare intervals of clearsightedness—and some two months after the events chronicled, Edison was the recipient of a gleam of capricious kindness. Human nature is much the same in all ages, despite the accidents of birth and environment, and although the Nineteenth century has no dragons to slay and no enchanted princesses to rescue, it still affords scope for the dauntless heart and the ready hand.

Edison was standing on the platform of the Mt. Clemens station pondering, as it happened, over the multiform uses of telegraphy, and how he, a friendless and penniless lad, might best apply himself to the mastering of that valuable art, when he became aware of a vision more terrific than ever flashed on the vision of Perseus or Hercules, St. George or Sir Launcelot. Rounding the curve, with glare of headlight, with maniacal shriek and clanging of metal-



SAMUEL EDISON AT EIGHTY-EIGHT YEARS OF AGE. EDISON'S FATHER.

lic fetters, came the express locomotive, and right in the path of this iron Polyphemus lay an innocent and helpless child, the three-year-old son of the station master, Mr. J. A. McKenzie. Edison's swift mind and muscles stood him in good stead. To dash himself in front of the impending peril, to seize the child in his strong young arms, and to fling himself and it into byways of safety, was a work almost as instantaneous as the action of his own beloved fluid. The boy's modest and generous nature would have led him to make light of this heroic feat, but the gratitude of the station master was fully aroused, and he insisted upon repaying Edison in the only way which lay in his power, that of perfecting the ambitious lad in the coveted art of telegraphy. Edison plunged with characteristic ardor into his new pursuit.

Employment had again fallen into his way, monopolizing his daylight hours, but he devoted the night to the prosecution of telegraphy, returning by freight train to Mt. Clemens in order to avail himself of Mr. McKenzie's kindly and able instructions. In five months he had acquired such skill as to command $25 a month in the Port Huron telegraphic office, quite an important position for a lad of fifteen.

He remained at Port Huron six months, giving evidence of phenomenal industry and skill, of which one instance will suffice. The press at that time were on the *qui vive* to secure a correct report of the Presidential message to Congress, and offered the Western Union agent $60 to obtain it. Edison was deputed to receive it, with the promised reward of $20, but no sooner had the task been performed, with all the lad's accustomed ease, than the bargain was disowned, together with all claims for extra work. The greed and dishonesty of this man so disgusted Edison that he left abruptly for Stratford, Canada, in the capacity of night operator on the Grand Trunk Railroad. The circuit manager was somewhat of a martinet, and the service of the strictest, but Edison's ingenuity enabled him to evade at least one of the regulations without prejudice to the service. With a view to maintaining ceaseless activity during the drowsy hours of night, the operators were required to report the word *six* at inter-

OUR LUCKLESS HERO FOUND HIMSELF ON THE PLATFORM WITH HIS HOUSEHOLD GOODS RAINING ABOUT HIS EARS. [SEE PAGE 9.]

vals of half an hour. Edison constructed a wheel, inscribed with Morse characters, which, under the propulsion of a good-natured watchman, supplied the office call while the inventor slept.

It is possible that the success of this device rendered Edison overconfident, for detection followed on the next evasion of duty. The operators were required, when so notified, to stop certain specified trains, and then to inform the train despatcher of their arrival. Edison, unaware of the limited time at his command, reversed the order, and notified the train despatcher before signalling the train, which passed through the station without stopping, and was nearly out of sight when he returned. Realizing, too late, the danger of the situation, he endeavored to reach a certain freight depot at the bottom of the station, knowing that trains often stopped there, and hoping to arrest their further progress; but the night was dark, the way beset with obstructions, and the lad too fearful and agitated to see clearly. The result was that he fell into a culvert clearing, bruising himself severely, and occasioning a delay which enabled the train to pass entirely out of sight.

Bleeding and breathless, he presented himself at the telegraph office, and word was instantly flashed over the lines, but too late to have prevented the dreaded collision, which, however, did not occur, owing to the vigilance of the respective engineers. An infringement of duty so grave, and involving such fatal consequences, could not be allowed to pass unpunished, and Edison was speedily summoned to the presence of the general manager, Mr. W. J. Spicer, a very Radamanthus of icy severity. Edison thus describes the interview, infusing into it a spice of fun which was probably conspicuous by its absence on the occasion itself. "Young man," said Mr. Spicer, "this offense of yours is a very serious one,

"ROUNDING THE CURVE, WITH MANICAL SHRIEK, CAME THE EXPRESS LOCOMOTIVE." [SEE PAGE 12.]

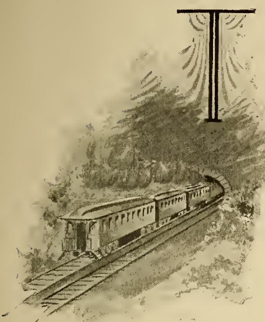
and I think I shall make an example of you. I can send you to the penitentiary for five years, and——" Just at this moment," continues Edison, "two English swells came in, and Mr. Spicer, now all affability, rose to greet them. They engaged him in conversation, and as I couldn't see that they really needed me around there, I slipped quietly out of the door and made for the freight depot, where I found a train about to start for Sarnia. I knew the conductor, told him I had been down in Toronto on a little holiday excursion, and said I'd like to take a run up the line with him as far as Sarnia. He told me to jump aboard, and I wasn't long in getting out of sight, but my pulse didn't get down to normal work until the ferry boat between Sarnia and Port Huron had landed me in the latter town. I haven't been in Toronto since that time."

Returned to Port Huron, Edison brought his newly acquired knowledge to bear on a novel set of circumstances. The winter had been an unusually severe one, and toward its close, the masses of ice had formed in such bulks and with such tremendous force as to sever the cable between Port Huron and the Canadian city of Sainier, rendering the river, which was a mile and a half wide at this point, totally impassable, beside impeding all telegraphic communications. Edison's exhaustless brain was stimulated by the demands of the situation, and jumping on a locomotive, he sent the incisive whistle over the ice-bound waters to the rhythmic cadences of the Morse alphabet—"Hallo, Sarnia, Sarnia, do you get what I say?" No response from the Sarnian operator. Again and again the short and long toots shaped themselves into the dots and dashes of telegraphy, until at last, while the spectators on the river bank quivered with pent-up excitement, the answer came, clear, cheery and intelligible, and the connection between the two cities was resumed. This little episode, brief and and simple as it was, brought the young operator into public view, and laid the foundation of his international fame. Edison's abilities as an operator were now sufficiently well known to carry weight, and he had little difficulty in obtaining employment. Positions at Adrian, Mich., and Fort Wayne, Ind., were successively filled, and with considerable credit, although it must be confessed that Edison's love of fun and greater love of experiments led him to violate the essential rules laid down for the guidance of the operators. At Indianapolis these pleasing irregularities resulted in serious trouble, but his unpopularity and subsequent discharge probably weighed very little upon his mind, counter-balanced as they were by the fact that his increasing skill and deepened insight led him at the age of seventeen to the invention of a telegraph instrument, susceptible of transferring writing from one line to another, without the assistance of an operator. This automatic repeater is thus described in a recent telegraphic work as "probably the most simple and ingenious arrangement of connections for a repeater known, and has been found to work well in practice. It is especially good and convenient where it is necessary to fit up a repeater, in an emergency, with ordinary office instruments." The ferment of discovery was now working in Edison's veins, militating against the steady, uneventful grind of daily routine; at an age when food and sleep are most essential to mental and physical development, he ruthlessly curtailed both, burning not only the midnight oil, but trenching on the gray hours preceding the dawn, a time when, as physicians tell us, vitality is at its lowest ebb, and most dependent on "nature's sweet restorer."

(*To be continued.*)

COMING DEVELOPMENT OF ELECTRIC RAILWAYS.*

By Frank J. Sprague, President American Institute of Electrical Engineers.



THAT electricity is in its infancy is a trite but mistaken saying. It dropped its swaddling clothes when Morse sent the first telegraphic message. It put aside dresses and pinafores when the dynamo machine and arc light were invented. The incandescent lamp, the telephone, the art of welding, the transformer, are incidents of buoyant youth. The modern electric motor and electric railway mark a vigorous manhood. The truly marvelous development of electric applications of every kind, the accomplishment of many things which in ignorance of the very art, or lack of knowledge of what are now well-known facts, and more particularly the great commercial development of the transmission of power, whether for stationary purposes or for electric railways, has led to many a foolish prediction and idle boast.

This is no age of inspiration, nor time for hopes never to attain fruition. It is above all things a practical age, perhaps too practical, but nevertheless one in which commercial enterprises to be successful must promise either a new field of development or economics in older fields. As the orthodox few have been waiting in sublime faith for many centuries, and will wait for many more, for the fulfillment of ancient prophecies, so too will impracticable electric enthusiasts vainly wait for the millenium when investments are boundless, performances limitless and efficiencies unity.

It would perhaps have been proper in making my inaugural address to so representative a body as that of the electrical engineers that I should touch upon the special discoveries and experiments which have recently attracted attention, but there have been so many enthusiastic and brilliant workers that neither the time at my disposal nor the knowledge I possess would permit me to do justice to their work ; hence it seems better to take up a subject with which I have been more particularly identified, which to-day commands so much attention, and concerning which there are such conflicting opinions. While finding encouragement in the achievements of our profession, I think the time opportune for a word of caution.

Electric street railways are no longer experimental, nor is their success problematical. Their history for five years is that of an almost unequaled development. Almost within a decade has occurred the first working of a practical electrical railway. In a third of that period there have been put in operation or under contract more than 450 roads, equipped with nearly 6000 cars and over 10,000 motors, and with over 3000 miles of track. There is made a daily mileage of not less than 700,000 miles, and over a billion of passengers are carried annually. At least $75,000,000 have been invested in this industry alone; 30,000 horses in a single year have been relieved from the slavery of street car propulsion; stables are disappearing and streets becoming cleaner; luxurious cars are running on smooth, well-built and rigid road-beds. Dividends have been increased, expenses re-

* Address delivered at meeting of American Institute of Electrical Engineers.

duced, investments enlarged, the unproductive has become productive, the impossible possible. Land values have been increased, habitable limits extended, homes created and time saved.

We no longer hear seriously of the dangers of the trolley wire, the failure of service. The time has come when legitimate investment is amply warranted. Electric street railway construction has become a matter of engineering, not experiment. Not only have the smaller towns adopted what is the only available means of current supply, but the larger cities are following their example. St. Louis and Baltimore, Minneapolis and St. Paul, Buffalo and Rochester, Boston and Brooklyn have fallen into line, and latterly even Philadelphia seeks an improved street service, and in New York public interest is being aroused. In the latter city it is, of course, impossible to tell how successful will be the attempt to introduce electric propulsion. There is a strong and in many respects a legitimate objection to overhead wires. Many unsightly poles and badly strung wires have disappeared and their place been taken by an underground service. The general feeling of opposition to poles and wires, ought not, however, to act as a barrier to such reasonable and proper introduction of an overhead system of supply as the conditions now existing in that city very properly warrant. I have frequently pointed out the fact that the greatest good can come to the greatest number, especially in the overburdened condition of transit which there exists, if certain of the lines were electrically equipped, wherever, in fact, there would be no street obstruction.

In broad streets, where the tracks occupy only a small portion of the street and are near together, a line of poles of ornate design with arms projecting on either side, can follow the centre of the street, the same poles being used for lighting. Such a street, it seems to me, is Eighth avenue. Then, too, where there is a middle division or park, such as exists in many boulevards, and which is now used for telegraph poles, there is opportunity for an electric construction which would be entirely unobjectionable. On streets occupied with elevated structures, those structures themselves would be used for a practically rigid overhead system.

Among the numerous places in New York where an overhead system could be put in perfect operation, are Central Park, west, the boulevard from Fifty-ninth street up, a part of the First and Second avenue lines, the Third, Sixth and Ninth avenue lines, and all the suburban extensions from the annexed district. I am not sufficiently familiar with the streets of Chicago, which is the last remaining city which must consider electric street railways, to suggest a plan. In these large cities, however, one condition should be insisted upon, and if this condition is met in the proper spirit, then much of the objection which has been raised against an overhead system must necessarily disappear.

The construction must be of the very best. The only overhead line allowed should be a contact wire with sufficient strength ; the main conductors and the feeders should be put underground in proper conduits. There would then be overhead only a wire necessary for the smallest duty and of the requisite strength. In many streets, of course, the cable will hold its own until an electric conduit or surface contact system shall be proven satisfactory. Impressed by the great development of this industry and brought face to face with the changes it has wrought, the query is continually made—will the electric motor replace the steam locomotive? It is similar to the older question—will the telephone replace the telegraph? Will the electric light annihilate the gas system—and in all soberness a like answer can be made—It will not, but it will, as the electric light and as the telephone has done, create a field of its own, and will replace a portion of the service now done by steam. It seems to me that the growth of electric railways will proceed something in this order : First, the street systems in the various towns, then connecting lines between adjacent towns following the

line of highways, then longer connecting lines, either on the track of existing steam lines, or growing bolder, on exclusive rights of way on the same order. Then will come suburban traffic on a larger scale, and freight transfer system, and finally the more ambitious project of trunk line service under limiting conditions, such as I will specify. It has been very properly said that a man will make the first long ride on electric railways by transferring from one town system to another through connecting links, rather than on individual roads.

This is precisely the process by which great steam systems have been built up, although, of course, starting on a larger scale, and it is but natural that this shall be one step in the development of electric railways. But evidently this natural process of evolution does not offer scope enough for the more enthusiastic, and we are now and again treated to an ideal electric road to be built on plans boldly defying both geography and the abodes of civilization. An air line route according to rules of surveying allowed only in Russia and on the desert of Sahara; abolition of the grades and street crossing; rigid and continuous rails; loaded cars of light weight, each operated by its own motor and making few or no stops; unlimited potentials and undiscovered resistance to insulation; new physiological and engineering laws; indestructible machinery; unheard of powers of braking and new methods of train operation and signaling; around all a clear atmosphere; above all a perpetually smiling heaven, and behind all an unlimited bank account and the unlimited confidence of the investor. These are some of the characteristics of such a road, but perhaps it is only fair to ask, given some of these conditions, what would be the capacity of steam traction?

No one will question the capacity of a motor to do the necessary work required, or to make a speed superior to that of the steam locomotive, provided sufficient energy be delivered to its terminals, but we must deal with existing or probable methods of supply. It is true that the speed at which a train is propelled by steam has only increased about fifty per cent in sixty years, for in 1832 the "Matthew Baldwin" often made a speed a mile a minute; but we must not confound speed with power, for while the maximum speed has not been so materially increased, the endurance, the perfection of the mechanism and the economy of performance have made great strides, and the increased speed, which is by no means the maximum possible of a locomotive *per se*, has been attained at much higher powers, and the schedule time has been shortened principally by cutting down grades, straightening curves, filling up ravines, abolishing trestle works, replacing wooden bridges by permanent ones of iron or stone, by the use of heavier and stiffer rails, better switches, improved methods of automatic signaling, the interlocking switch and signal system, and the abolition of grade crossings; in short, by improvements in details and management which permit of higher speeds on more extended sections of road because of greater safety, lower traction co-efficients and a greater degree of confidence possessed by the engineer.

All these things are necessary for high speed electric railways, and any general improvement that will be of benefit to the latter must necessarily be of service to the former. Now, any predictions which are made concerning the future of electric propulsion, either in ignorance or disregard of the possibilities of steam duty, and the limitations necessarily existing in all systems of transportation, deserve and will receive little consideration. Hence let us note a few of recent locomotive performances.

Almost every one is familiar with the remarkable run recently made by a Schenectady locomotive hauling a special train on the New York Central Railroad, when the distance of 439½ miles from New York to Buffalo, was made at an average speed of nearly sixty miles per hour, and which was the precursor of the Empire State express, which makes the regular run at an average speed of over fifty-two miles per hour.

More recently we have accounts of an interesting record made by a well-known writer on two runs between New York and Albany, on which a large number of indicator cards were taken. The weight of the train was about 270 tons. The steam pressure varied from 160 to 170 pounds. From an inspection of about a dozen cards, the indicated horse-power varied from 551 horse-power at forty-four miles to 1120 horse-power at 78.9 miles. At sixty miles per hour, the train resistance is stated to have been fifteen pounds per ton, and at seventy miles, 17.10 miles per ton. About seven pounds of water were evaporated per pound of coal. A remarkable statement concerning this performance was made by Mr. Sinclair, which, while almost incredible, will, if borne out by an analysis of facts, prove to be something of a surprise to those who make their prophecies of the electric economies by comparative statements. In the description of these tests it is stated that the whole trip shows an indicated horse-power per hour for an average expenditure of only about 3⅛ pounds of coal per hour. This is far better than many stationary engines.

On the New Jersey Central road one schedule time is 86¼ miles in eighty-nine minutes, which is made where there are a number of necessary slackenings. On May 13th, the time was taken of the speed of a Baldwin compound locomotive for a considerable period of time on one of the regular runs. Ten continuous miles were made in 452½ seconds and five were made in 222 seconds. The fastest time taken was forty-four seconds, and the slowest noted was forty-seven. On February 26th a similar compound passenger locomotive running on the same road broke all steam records by running a mile in 39¼ seconds, or at the rate of nearly ninety-two miles per hour. At this speed the indicator cards showed 930 horse-power, and the drivers, which are seventy-eight inches in diameter, were making 395 revolutions per minute. In the very near future, I expect to have the pleasure of riding on a locomotive when going at these high speeds, and I presume my respect for steam locomotion will not be diminished thereby, nor, on the other hand, will my confidence in the possibilities of electric propulsion under the proper conditions. Experimental runs have been made with an electric locomotive at the rate of one mile in thirty seconds, that is 120 miles an hour, and I confidently expect some day to go at that rate. But it will be under special conditions and not on the regular trunk lines of this country, and it is the height of folly to suggest that these steam trunk lines are to be abolished. In making these very high speed runs, there is not much attempt at maximum economy of coal consumption, the necessity being to generate steam as fast as required by the cylinder, but on taking an average of five trips, I find that there was evaporated 7.19 pounds of water per pound of coal used, and 9.41 pounds of water evaporated per pound of coal consumed. The total weight of train varied from 213 to 241 tons. The personal equations of engineer and firemen necessarily enter seriously into steam operations, and this, compounded of course with the peculiarities of each engine, and the conditions of service, is shown in railroad reports. In this connection, I recently inspected a number of engine sheets. On one, which gave the duty of twenty-five engines, the average total cost per engine mile was 10.85 cents, of which 2.66 was for fuel. The total cost varied from 6.8 to 19.24 cents, and the fuel (wood) from 1.96 to 4.77 cents. On another sheet, giving the performance of twenty-two engines, the total cost per engine mile was 14.70 cents, of which the fuel cost 4.61. The total cost varied from 8.82 to 27.98 cents, and the fuel cost from 2.04 to 7.48. In still another, that of the performance of eighteen engines, the total cost per engine mile was 14.73 cents, of which the fuel (coal) cost 6.62 cents. The total cost varied from 10.04 to 22.52 cents, and the fuel cost from 3.82 to 13.84 cents.

In discussing the electric system there is often a confusion of statements with reference to economy. Despite the un-

doubted fact that the electric motor can probably be run at variable high speeds with less variation of economy than can the steam locomotive, we must not forget that in the latter we are considering the economy of the unit as a whole, not merely of the steam cylinders, but also of the boiler and the furnace. In electric propulsion a similar comparison of economies must take into account the variable duty of the central station and the losses on the line, as well as those in the motor, and where single units are used the variation in economy of the whole system would be much greater than in the steam locomotive. There will be only a reasonable fixed efficiency of the central station and the line, when the number of units is large enough to make the load on the central stations nearly constant.

Let us now consider another class of duty. Some time ago I made a very careful analysis of the work done on the elevated roads in New York city with a view of determining the coal consumption and the duty performed by the locomotives. At the time this investigation was made, now nearly seven years ago, there were in use on the Third avenue division sixty-three trains at one time, running at very close intervals. The weight of the trains was from eighty to ninety tons; the speed was often as high as twenty to twenty-five miles an hour; stops were made every third of a mile; in short, the duties demanded of the engines were exceedingly severe. The maximum indicated horse-power of the locomotives was found to average about 163 horse-power, although on occasions these locomotives have been worked up to 185 horse-power. Work was divided approximately as follows:

Acceleration in starting 59 per cent., lifting 2.43 per cent., and traction 16.7 per cent. The average horse-power exerted was 70.3 horse-power, considerably less than one-half of the maximum. The work on the line was so distributed that there was an almost constant total duty of about 4500 horse-power. The locomotives were on duty twenty hours, but used steam only six hours, and including all losses when standing still and the amount of steam used in braking there was a horse-power development for about 6.2 pounds of coal. I believe that these figures are entirely reliable, and they show a remarkable performance when we consider the class of duty.

An analysis of the coal expenditures showed that, with an efficiency of sixty per cent. and without any of the energy of the train being returned to the line, the relative coal expenditures between steam and electricity would be about in a ratio of two to one, but if the energy of the train was returned to the line to the extent which I believe it is possible, then the relative expenditure of fuel would be in the proportion of seven to two. Since the coal charge on the four divisions was at that time about $550,000, it can easily be seen that, independent of any question of saving in the care of the structure and any reduction of depreciation of the motor equipment, the fuel saving would be sufficient to pay a good interest on the cost of electric equipment and a large interest on the cost of electric equipment minus the value of the present engines. I have no reason to doubt the soundness of the conclusions I then made.

You will have in Chicago, however, a somewhat more advanced condition of affairs. A compound type of locomotive has been adopted for the elevated road service, and I believe it will show an increased economy over that of the operation of the New York roads. Consequently, in discussing the question of economy, it is necessary to get full information concerning the duty which will be done here. In discussing high speed possibilities and limitations, the testimony of Dr. Dudley as given in a discussion of a paper, February 24th, 1891, is interesting. There are, generally speaking, three distinct elements constituting the resistance of train movement on a level, and they have a most important bearing when we consider the operation of long or short trains, and at high speeds. One of these elements is the rolling friction

of the train in its bearings; with good rolling stock this is about eight pounds per ton. For all reasonable speeds it is probably fairly constant, provided the lubrication is good. Another element is that of air resistance which varies with the shape of the forward end of the train, the condition of the air, the direction of the wind, and the velocity of movement. The third I may call the train lifting or rail bending effort, which depends upon the weight and swiftness of the rails and solidity of the road-bed.

Dr. Dudley stated that on the New York Central system he found that trains of about 250 tons when running at a speed of a mile a minute, have a resistance of from ten to twelve pounds per ton, but that on short trains of two or three cars the resistance sometimes ran as high as thirty-five or forty pounds per ton. This is probably due not to any change in the friction of the bearings, but to the fact that the air resistance enters as a much higher component of the total. It at once emphasizes the fact that the operation of short trains at high speeds must, no matter how good the track or how favorable all other circumstances, be with a train resistance higher than required by long and well vestibuled trains. Such a shape can be given to the front of an electric locomotive as will make the air resistance not over one-half that presented by a plain surface of equal cross-section and perpendicular to the line of motion, but even this fact does not alter the other, that the resistance per ton must be higher for small trains than for large ones.

Mr. Dudley further stated, in speaking of the influence of stiff rails, that the difference in power required on the "Chicago Limited" when running on an eighty and a sixty-five pound rail was from 75 to 100 horse-power per mile, that is, somewhere between ten and twelve per cent. of the power actually developed, and he estimates that with a 105-pound rail, which is nearly twice as stiff as the eighty-pound rail, there would probably be saved another 100 horse-power per mile, making a total saving of a quarter by less than doubling the weight of the rail. In his opinion it is perfectly safe to run a steam engine 120 miles an hour on this heavy rail. Such rail improvements increase speed possibilities with present engines, but we have not related the limit of steam duty. Almost all the locomotive work of the United States has been done up to the present with simple engines. Their weight and capacity has been increased, their steam pressure raised until the standard is now about 140 pounds. Within recent years, however, the compound locomotive has come into use, and there is a comparatively large number of them in daily service. The steam pressure has gone up to 180 pounds as a standard, working sometimes as high as 200 pounds, but these are by no means the limits of steam pressure.

On the Paris, Lyons and Mediterranean railway the standard for steam pressure for compund locomotives is 250 pounds. The compound locomotive has still its battle to fight, but I think it would be a rash man who will say that the days of still higher steam pressure are not to come, and that the triple expansion locomotive will never exist. Speed, capacity and coal economy are, however, not the only questions to be considered in railroad operation, and in discussing the general subject, it will be found that the signaling and braking questions at high speeds are serious ones. Undoubtedly an electric train with distributed motors, making the weight of the train available for traction, could by using the motors as dynamos to return the energy of the train to the line from the highest to mean speeds and then on a local circuit, be more quickly and effectually slowed down and stopped than where shoe brakes are used, and both methods of course would be available. But if using a motor ahead of a train then there will be comparatively little difference in the stopping power. When riding at sixty or seventy miles an hour, it is a very quick stop to bring a train at rest in less than 2000 feet. This is often as far as any signal can be made out, especially

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when the weather is at all thick. Hence we may expect to find on electric railroads if high speeds are to be attained, and quite possibly also on steam railroads, an extension of automatic signaling so that trains indicate on more than two sets of signals. At present the practice is to divide the line into sections, and when a train passes a certain point it sets danger and cautionary signals, dropping the danger signal on the section just preceding, and the cautionary signal on the one beyond.

Turning now to the greater powers, we must not confuse the terms "large powered" and "trunk line" work.

These are two statements which I think will need no corroboration. If we had a continuous train movement completely occupying a track system, there can be no question but that its operation from a central source by electricity would be more economical than if operated by steam locomotives. So, too, if a large number of units in reasonable proximity are moved, and the stopping and starting so regulated that the total demand upon the central stations is fairly continuous and equal, then there is no question as to economy of electric propulsion as compared with steam. On the other hand, the operation of a single or very few units over a long distance would be so uneconomical and afford so small a return on the investment required, as to make it prohibitory. Between these two, lies the condition of operation where steam and electricity meet on planes of equality; as the number of train decreases, steam operation is the more economical; as the number increases, electricity must be preferred.

In discussing the use of electricity instead of steam, a well-known steam engineer recently stated that in his judgment it must be conceded that the electromotive force for the propulsion of cars will not be economical except for suburban traffic, and upon certain sections of important trunk lines, like the New York Central between New York and Albany, the Pennsylvania system between New York and Philadelphia, and other lines of like character where it is necessary to dispatch a large number of comparatively light trains every day, and at short intervals. The principal field for a power of this kind would be in suburban service long enough to make the ordinary street electric cars unpopular because of the time required, and in such cases as these mentioned above; also for moving freight trains in cities; that is, for the performance of transfer service. This is precisely in line with the arguments which I have advanced from time to time, and which I illustrated in a paper before the National Electric Light Association at its convention in Kansas City, where I outlined the possible service between New York and Philadelphia, which I believed to be practicable, and to which I will again refer.

I must repeat that it narrows itself down to the one question as to the number of trains operated between two terminal points. Make that number of trains sufficiently large, and the electric motor is the best means of propulsion, whether for high or low speed, whether for large or for small cars. Decrease this number, and we must rely on steam propulsion, or, to put it in another way, the answer to the query, Will electricity take the place of steam for railroad purposes, is: Only in part, and then only when the number of units operated between the terminal points is so large that the fuel economy would pay a reasonable interest and depreciation of the necessary cost of the central station and the system of conductors.

Of course I do not in this general reply consider those special cases where advantages are to be gained for which there is a return for capital in another direction. Such a case is that of the Baltimore tunnel, where the investment and cost of operation will be greater than that for steam propulsion; in fact, there will practically be no economy in power, because the steam locomotives are not done away with, but simply unused for a period of a little over a mile. There is in this specific case, however, the incidental advantage of doing away with the necessity of a ventilating plant,

and yet getting rid of the annoyances incidental to tunnel service.

Trunk line transportation being a great problem, we should not attempt the simultaneous solutions of all the questions involved, but instead, determine what those questions are, consider their sequence and the probability of success, and solve them in their order.

Every system has its limitation. The electric is not exempt from this law, and hence it will set forth what are well-known limiting laws concerning the transmission of energy. They have been stated time and again, but somehow or another, people often lose sight of them in discussing the question of investments in large electric railways, so that I think it would be well perhaps to restate and emphasize them.

The weight of copper necessary to transmit a given amount of power with a fixed loss will vary inversely as the square of the electromotive force used.

The distance to which it can be transmitted over a conductor with a given cross-section will vary directly as the pressure.

The weight of copper necessary where the supply station is in the centre of a system is only one-quarter that required if the station is at one end.

The weight of copper will vary inversely as the square of the number of supplying stations properly placed.

The electromotive force required will vary inversely as the number of stations.

Lack of knowledge of these simplex and unalterable laws have led to much misconception of electrical possibilities, and these have not been confined to electrical engineers.

In many of the suggestions which have been made even by practical steam engineers, there has been an unnecessary confusion of the practicable and impracticable, and the specific object which should have been borne in mind has been lost sight of.

Committees have drawn impossible specifications for trunk line service, and demanded of electric motors a capacity and performance superior to that of the best compound steam locomotives. I unhesitatingly pronounce any attempt to build some such machines, for the present, certainly unnecessary and impracticable. The service thus suggested, if at all needed, will for many years be better performed by the steam locomotive than the electric.

Leaving out of present consideration trunk line work, there are three problems requiring solution in the application of electricity to propulsion on a large scale under conditions existing, for example, in Chicago or any other place where there is a movement of a large number of trains on more or less complicated tracks, as will be found at almost all terminal railway stations. They are :

FIRST.—The development of an electric locomotive of ample power which shall be as readily controlled as the steam locomotive, and shall be reliable in operation, and shall show a high economy. Of course such a machine must have all the adjuncts which are necessary for train movement.

SECOND.—A system of conductors and method of supporting the same which can be relied upon for ample supply of current and absolute certainty of continuous contact at all speeds on curves, switches, cross-overs and the multitudinous combination which exist on yard tracks.

THIRD.—A system of automatic block signaling, which while effective for steam traffic, will not be thrown out of operation by the use of tracks as conductors of electricity for a general supply. This is a more serious question than is at first considered, for this use will materially interfere with, if not absolutely destroy, the utility of what is known as the rail circuit system.

This third problem is one which must necessarily follow the development of the other two, as the automatic signaling systems now existing have followed the development of steam practice.

While I am not by any means thoroughly familiar with the various methods of automatic signaling, I believe I am justified in saying that there is none at present existing which will meet all

the requirements of railway practice, and which can be operated on tracks used by both steam and electric locomotives, where the rail is used as a part of the supply circuit. Some of the best known systems of signaling would be rendered entirely inoperative.

As difficult as it may seem to devise such a system, I believe that it certainly can be developed, but only properly so on a section of track which is more or less experimental, on which at the time of operation automatic signaling is unnecessary, but which is actually operated by both classes of service. Such an experimental section would be a combination of single and double tracks, with all the varieties of curves, crossings, switches and ladders, such as would be found in any large yard.

It will probably be found necessary to erect a variety of kinds of conductors. From the most careful consideration which I have been able to give to the subject, I believe there is one way, and only one way, in which the current can properly be supplied in any complicated system, and that is from the overhead conductor, practically rigid in character, following very nearly the centre line of all tracks and switches with no movable overhead parts, and with return through the rail. The locomotive would then practically be moving between two electric planes, the lower being the guiding one. I know there has been a great deal of talk about other possible systems of supply. We have heard much of the charged rail using low potential currents supplied at frequent intervals by motor generators driven from a central station. Since we have discovered no conductors devoid of resistance, and the art of welding is not particularly applicable for railway service where moving contacts are a necessity, little credence need be given to any scheme of this character.

We heard again of the central rail supported on posts in wells between the tracks. A centre rail may be acceptable on a system like that of the elevated roads, but in ordinary railroad work any ditch intended to drain a track so as to keep insulators dry and keep snow away from them would probably so open the track that any moisture and frost would cause upheavals of serious character, and the cost of maintaining the track would be prohibitory. The use of snow machinery for keeping the track clear would be impossible, and anything underneath the cars is in the most exposed place for sustaining damage by defective rolling stock, and continually liable to all sorts of mechanical injuries and accidents with all the evil results of interruption of currents, short circuiting and stoppage of traffic.

Another system which has been proposed is that of conductors supported on posts alongside of the track and elevated but three or four feet above it. While not open to so serious objections in the matter of insulation as a centre rail system, its use is manifestly not to be thought of where there are crossings or switches. Even on a straight, clear track in a hard climate there would be most serious trouble in the matter of clearing the tracks from snow, and at the grade crossings in this country gaps in the conductors would be too great for the contacts on a single locomotive to stand.

Some time ago I was requested on behalf of a well-known financial man, whose enthusiasm as to the possibility of electric traction is well known, but who is withal a most practical railroad man, to inspect various railroad terminal tracks in this city with a view of, first, the substitution of the switching work now done by a part or all of the 1800 or more switch engines by electric motors, and eventually the operation of suburban service.

Considering the railroads merely as they exist a number of systems in Chicago, in the space of about two square miles, or more exactly, one and a half miles in length by three-quarters of a mile in breadth, it is no exaggeration to say that there is or will be not less than seventy-five miles of track, and switches and crossings, with their various combinations, almost innumerable.

I went over and over some of these

tracks with the one thought in my mind—how can the current be delivered to the locomotives, and how can the automatic signaling be done? And I was forced to the one conclusion to which it seems every man who makes the investigation must come, and that is that the overhead system of supply is the only one, but that it must be as substantial and thorough in character as that of any other part of the system, and that in view of the cost, such a system is only permissible where the number of units operated is large and continuous. These conclusions are not new, but they have been emphasized by the particular problem which is here represented.

Intimately connected with the question of conductors, and one of the most serious ones which has to be met by the electrician, is that of potential. The personal danger limit of continuous or ordinary period alternate currents is pretty well determined, and it seems generally admitted by constructors that the danger limit for the continuous current machine, with its commutator, is about the same as the personal danger limit.

Hence we meet with two dilemmas. If using continuous current motors, we are limited to a difference of potential per machine of 1000 to 1200 volts, and we can, so far as safety of the machines is concerned, only probably go above this limit by putting the motors in series, precisely as has been proposed for long distance stationary transmissions. If this is not done, then we have the introduction between the transmitting dynamo and the receiving motor of a motor generator system, another pet theory which is often suggested, but which I unhesitatingly pronounce as so uneconomical as to be impracticable. If using an alternate current system, then converters must be used, either distributed along the line and supplying the working circuit or placed upon the locomotive to safeguard the motors. While the use of a converter under these conditions is not as objectionable as the use of a motor generator, it cannot commend itself as a very practicable scheme, and certainly in view of the fact that no single phase, single alternate motor promises, up to the present, serious success. For the present, and, I think, for a long time to come, we must confine ourselves to the consideration of railroad problems, where continuous currents are used, and where the traffic between two points is sufficiently large to justify the investment in central stations and conductors which would be required for the operation of such assistant. There are two methods of propelling trains electrically, one by following steam practice, that is, by building a motor and hooking it to the head of a train, the weight of the motor being such as is required for the necessary power and traction when grades or slippery tracks are encountered. From all that has been developed up to the present, to get the control that is necessary and to build the machines safely, the electric locomotive will weigh nearly as much per horse-power as the steam locomotive. This weight can be better distributed, but I do not think, if steam practice is followed on trunk line service, that there could be any very material reduction of weight of train.

The other plan is to have each car propelled by one or more motors. This would be the ideal system so far as propulsion goes, provided the electric motor was unlike all other mechanical apparatus, and that it never failed, and if a number of machines could be as well taken care of, cost no more and show as little depreciation as fewer machines of larger capacity operated as a unit. Should we ever arrive, as we hope, to possession of a single circuit alternate current motor, then in view of the simplicity of its control, we may fairly hope for the distributed motor system. But here also the capacity and likewise the weight of the motor being determined by the total duty done, the weight of train limit would not be decreased, but rather increased. If, on the other hand, single units are used, the query naturally arises, what form would the electrical locomotive of the

future take? I do not think this is by any means settled; undoubtedly gearless machines will be used, but whether they will be mounted directly upon the axle, or whether they will movably inclose the axle and be flexibly connected to it while their weight is carried on springs on the truck, or whether the motor will be carried on the truck frame and connected to the drivers by the ordinary coupling rods, are questions which will be determined eventually by the depreciation per car mile upon the motors, trucks and road-bed as well as by the speed to be attained. Whatever the method of mounting the motor is adopted, for reasonable weights and powers, a 2-axle truck will be used, but where large powers and weights are necessary, two such trucks will be coupled together so as to keep the weight upon each wheel within limits, and this will carry a cab containing the regulating and collecting devices, and so shaped as to offer the least resistance to air pressure and high speeds. I have never advocated the use of a connecting rod in transmitting the motion from an armature to a driving axle, but I think it fair to say in this respect that the so-called hammering effect on the rails, said to take place in the ordinary locomotive driver where the weights are counter-balanced, exists more in imagination than in fact, and that the chief trouble in the use of the connecting rod is the change of direction of its movement. Among the roads that are ripe for the electrical engineer, and on which in the near future I hope he will demonstrate he has a most legitimate claim, are the New York elevated and Chicago elevated, the handling of the trains on the New York Central and Harlem roads below the Harlem river, the long talked of rapid transit road of New York, the Metropolitan underground road of London, the proposed tunnel roads in London, Paris and Berlin, and coming more immediately home, suburban service such as that of the Illinois Central Railroad, a most ideal track for the electrical engineer, and last, and as it will prove one of the most important, the operation of the terminal and warehouse systems for the interchange of freight on the lines entering a city situated as is Chicago. Taking this last, we have here a definite problem, now performed in a more or less satisfactory way by steam service. It is a problem large enough of itself. It has little connection with electric trunk line service, and the present impracticability of the latter has little bearing upon the thorough practicability of the former. Eighteen hundred or more switch engines, many of them on duty twenty-four hours a day, a large portion of the time standing idle, puff their foulness into your overburdened atmosphere, because from 80 to 90 per cent. of all the freight that comes into the depots of this city ought never come inside its limits, and would not were there a practical way provided to transfer it from one railroad to another outside the city limits. It has been suggested, and it seems to me a most feasible plan, that there shall be established a vast system for interchanging freight on the various railroads by a great six track crossing belt road which shall form a common zone of transfer either by itself or in combination with freight warehouses or storage yards. Undoubtedly there are many difficulties in the way, but from an electrical standpoint there is absolutely no question but that such a system of belt line is practicable.

With such unsolved problems, such abundant fields, I deem it unnecessary now to attempt to build electric locomotives to pull trains of great weight 100 miles an hour, or to develop a system of conductors for trunk line service which is not possible for yard duty, or to consider a central station or track equipment for a duty never required. This problem is in a measure an experimental one, which being carried to a certain measure of success will clearly point the way for a future development and outline its limits. I may be pardoned perhaps if I take radical views in some matters of railroad practice. I have fortunately, or otherwise, been thrown into direct touch with all the larger work which is to be done in this

country during the coming year, and it gives me pleasure to announce, what many of you know from the current news of the day, that there will probably be in operation in the United States within twelve months not less than five locomotives varying from seven to twelve hundred horse-power, and from 45 to 80 tons in weight. The character of the work done will vary. In that work in which I am most concerned from a personal standpoint, a 700 horse-power electric locomotive will be built for experimental work, and to attempt to solve as far as may be the various problems which are involved in railroad practice in Chicago. If my judgment is followed there will be an experimental section of track in the form of a loop about thirteen miles long with eighteen miles of rail, and with every variety of single and double track construction, and simple and compound crossings and switches.

On this I hope to see erected such varieties of overhead construction as may be found best to meet the various kinds of service, and where the railroad problems on tracks jointly operated by steam and electricity can be developed in the most satisfactory manner.

On this track there will be not only this locomotive, but also one of equal rated capacity supplied by one of the larger manufacturing companies.

The duty demanded of these machines will be severe. They will be required to haul a train of not less than 450 tons, at thirty miles an hour, up a grade of twenty-six feet to a mile.

They will probably be required to develop their full rate of capacity at all speeds between thirty and sixty miles per hour, and if there is sufficient track room they will be driven at a speed of at least seventy-five and perhaps 100 miles per hour for short distances. The potentials used will be nearly double that at present obtaining in street railway practice.

A still larger problem, so far as power goes, although not in the variety of conditions which will have to be met, will be that recently taken for the operation of the belt line tunnel now being constructed in Baltimore to avoid the necessity of boat transfer at Locust Point. The duty of the motor will be to propel the train with engines coupled on, but not in operation, through a tunnel about 6000 feet long.

The conditions require the motors, which will weigh about eighty tons and have a capacity of about 1200, to propel a 1200 ton freight train up a grade of forty-two feet to the mile at a speed of fifteen miles. Passenger trains of 450 tons weight must be regularly started from rest twice in the tunnel on this grade, and in an emergency the freight train must be started. The draw bar pull under regular duty, and when not starting, may be as high as 32,000 pounds.

Perhaps the traffic from New York to Philadelphia affords as good an example as any of what may be done on regular passenger service provided the track is clear enough.

For this I some three years ago, and again in the *Forum* of September, 1891, outlined an electric express service, with a method of supply through a rod carried above the car and a return circuit through the rails and earth.

The current was to be supplied from one or more central stations, equipped with high-class triple expansion engines, driving multipolar dynamos directly coupled. What the electrical engineer and the railroad man as well need to know is whether the electromotive force required on the line, and the number of stations necessary would be prohibitory.

No attempt was made at an excess of speed, but I confined myself to the average speed of a mile a minute for a distance of ninety miles, and considered a through service only. I assume a total weight of copper of only about two-thirds that which exists on the long distance telephone line between New York and Boston. The trains were to be two car units, leaving every ten minutes.

I found with these conditions the stations and potentials would be about as shown in the following table :

Station.	Miles Apart.	Potential. Two Wire.	Three Wire.
1	..	3,600	1,800
2	45	1,800	900
3	30	1,200	600
4	22½	900	450

If the three-wire system is used, that is, the rails as a compensating conductor between two trolley rods, then, with only two stations forty-two miles apart, it is seen that the potential is less than 1000 volts, and this we undoubtedly can handle.

I am not prepared to say that we may not use even a higher pressure, because I believe whatever is demanded in the interests of economy, all things being considered, will be used, but if we can reduce the potential to perfectly safe and reasonable limits by multiplying the number of stations, then those stations should be increased so long as the increase does not seriously affect the general expense of working. On a service of this character, where I have made the conditions distributed work, and the despatching of units at brief intervals, which conditions, I repeat, are absolutely necessary if we are to consider long distance transportation by electricity, such increase of stations as is advisable will not increase the cost of central station operation.

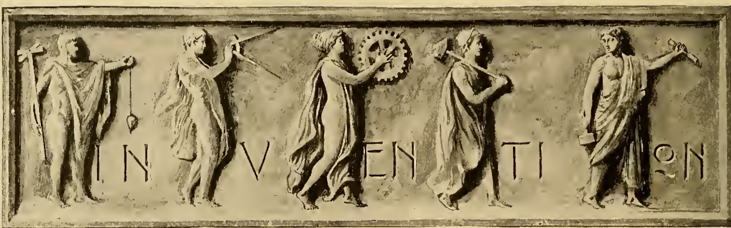
Such is the work before you, a work well meriting your best efforts, yet it is well to temper your enthusiasm with prudence.

Limit your attempts to the solution of those problems which will prove of practical benefit.

Do not chase rainbows. They are beautiful and poetic, but they have small place in the world's economies.

Remember that neither sentiment nor ignorance are winning cards, but lessened costs of operation for equivalent duty and increased returns on invested capital.

All this is said in no spirit of discouragement, for I yield to no man in my confidence in the future of electric traction. No new field is so rich, none more pregnant with great possibilities, but the growth of the work will be more expeditious and healthy if we separate the visionary from the real, the impracticable from the practicable.



NOTES ON NEW AND PATENTED INVENTIONS.--II.

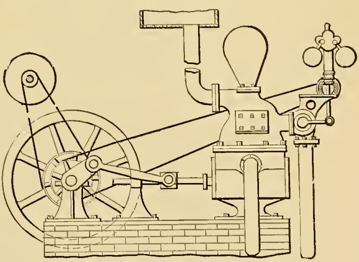
By John Richards, President of the Technical Society of the Pacific Coast and Editor of "Industry."

IN the first of these articles, which was printed in the October issue, the writer explained the scope it is intended they should cover.

U. S. Patent No. 473,949, May 3, 1892.

J. H. M'GOWAN—PUMP REGULATION.

This patent relates to a modification of pumping apparatus, in which an escape, or relief valve, operated by a centrifugal governor *G*, is placed on the discharge chamber, or in connection with it, so arranged that when the pump is started the water is merely circulated until the pump attains its normal speed, when the escape valve will close, and the discharge against the working head will begin.



NO. 473,949. PUMP REGULATION.

This, of course, takes place gradually as the relief or escape valve closes, so the load or resistance to the pump is assumed gradually as the speed increases. The main valve chamber of the pump is divided horizontally by a diaphragm, and there are two sets of discharge valves, so that when the pump is at rest, or running at less than its normal speed, the upper set of valves act as a check against the return of water by the discharge pipe *m*. The other or lower set of valves being then in connection with the valve *n* and return pipe *k*.

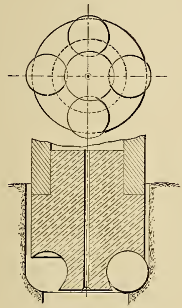
This arrangement is certainly one of value where a pump requires frequent stopping and starting, especially when working against a high head or pressure. The added attachments are inexpensive and simple, even when a centrifugal governor is included. The same result could, of course, be attained in a less perfect manner by a pass-over valve on the discharge pipe to be operated by hand. This the inventor describes in his specification.

The invention might be described as an automatic pass-over valve, or apparatus, as distinguished from one operated by hand, with also the difference of providing a check in the pump itself. The functions differ in respect to the

NOTE.—This series of articles was begun in the October issue (vol. 2, No. 12).

present apparatus being a regulator to determine speed below a point where the escape or pass-over valve is closed, or so long as it is in any degree open. The scheme is new in so far as any references at hand will show, and certainly is one of much merit in many cases where, as before said, a pump has to be frequently started against a considerable head. It would operate well in the case of centrifugal pumps working under pressure such as is common in the irrigating wells of California.

The invention also serves to remind us of how much may yet be learned respecting the movements of fluids, and



NO. 474,297. ROCK DRILLING.

that pumping is by no means the completed art that is commonly supposed.

U. S. Patent No. 474,297, May 3, 1892.

CARL HOFFMAN, PRUSSIA, GERMANY—ROCK DRILLING.

It has been a good many times pointed out that the hardest substances could be pulverized by rolling abrasion, and that, beyond a certain limit of pressure, a roller bearing was not only impracticable but the best means possible of abrading or wearing away the surfaces in contact ; also that this method is extensively applied in cutting hard material, such as glass and granite.

By examining the drawing above our readers will conclude it is a roller-bearing foot step for a vertical shaft, but on the contrary it is a drill for boring in rock. The drawing is one figure from the patent of Mr. Hoffman, who, instead of avoiding friction, proposes to create abrasive action of a very pronounced kind.

The darker shaded plug in the end of the core barrel is magnetized metal, employed to prevent the balls from falling out when the auger is lifted, otherwise the whole drawing is plain, and the scheme is by no means a chimerical one. Under heavy pressure, and when the detritus can escape as fast as loosened, the abrading action of the balls would be rapid, and the bore of the hole smooth and uniform. It is not likely, but is possible, that under certain conditions such an implement would make as much progress as diamonds when no core is removed.

We are not, however, discussing the merits of the invention so much as explaining rolling abrasion and the limitations of roller bearings, as exemplified in this case. The subject of rolling abrasion is a wide one, and, in the present state of the arts, a novel one, having no application of importance except under the Tilghman system, which will come up in a future place in these notes.

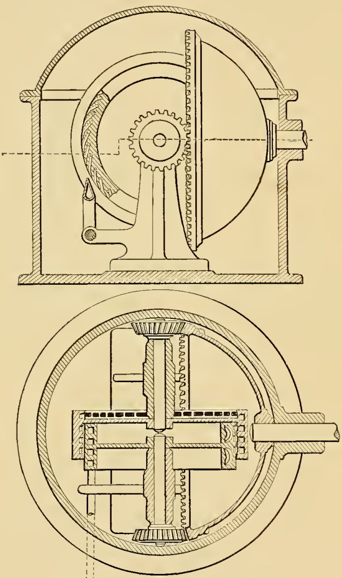
U. S. Patent No. 475,957, May 31, 1892.

G. J. ALTHAM—STEAM TURBINES.

The steam turbine, or impulse engine, is, no doubt, in future to have a place among operative machines of wide use. It is only four years since the Parsons' engine was presented commercially as a manufacture, and comprehended in its thermal or dynamic aspects all that we can hope to learn of steam inpulse as a means of power, but then, like common steam engines, the method is destined to go through a period of mechanical evolution, and, no doubt, a wide one, before it assumes what we call a standard type. Such a result is to be predicted, because the point where successive expansions must give way in favor of simplicity, and the avoidance of detail must be ascertained by experiment, and also by commercial considerations that are still slower in declaring themselves. Mr. Parsons continued to reduce the number of expansions, which means

also the number of wheels, in his construction, until only a third of the original number remained.

The Dow engine, invented in this country, which has but one wheel, and provides for expansions and reversal of the current by proceeding progressively from the centre toward the periphery of the wheels, and has thus hit upon a base principle, so to call it, that will, no doubt, be a characteristic of the final wheel, whatever other feature it may



NO. 475,957. STEAM TURBINES.

have differing from practice at this time.

Then, too, we must have the marvelous inventor who produces a horse power with half the fuel and half the steam, perhaps the inventor who uses the steam over and over again, and the one who by gearing "doubles the power." All these, and more, must come before we have steam impulse wheels in any settled form. Still we have, at this day, the guidance of scientific men who will supply the physical data attending on the use of attenuated or imponderable fluids, and the required functions of mechanical apparatus to best utilize their impulse expansive force.

Referring now to the motor or engine of Mr. Altham, shown in the two sectional views Figures 1 and 2, it will be seen that the wheel consists of two parts revolving in opposite directions at an equal axial rate, both gearing into one bevel wheel at its opposite sides. The steam ducts are curved and reversed in each wheel, passing from one to the other alternately, but retaining its original volume. In this latter respect the inventor ignores what both the Parsons and Dow engines employ as a leading feature, the expansion of volume and the area of ducts.

There is also the feature of the "steam joints" or fits between the moving parts, being in the plane of the axis the same as in the Dow engine, and differing from Parson's, in which the running joints are radial. There is a probability that there will be more difficulty in maintaining close joints in the Dow and Althan methods, and on these, no doubt, must depend, to a great extent, the efficiency of such engines, because with a fluid so subtile as steam, almost without viscosity, the smallest aperture will permit serious leaking.

It is, perhaps, too soon to predict, or write upon, the possibilities and limitations of steam impulse engines, but, as Professor Tyndal once said of another matter, "there is hope and promise" of a wide and important field for them, and conceding the economy of results credibly claimed in late experiments, we are far beyond the point of scoffing at this novel invention, resuscitated from the Greek age.

We have, as a beginning of this *renaissance* of impulse engines, the warrant of high skill and consummate knowledge of the physical and thermal laws involved in the labors of the Hon. C. A. Parsons, who has very carefully and persistently been experimenting and constructing impulse engines for five years past, and has so far succeeded as to found a permanent manufacture, and to supply electric generators, thus driven, for a

number of steamers, among them one or more of the Inman or International line, between New York and Liverpool.

De Laval, in Sweden, too, has brought these motors to a point of economy and success that is commanding much attention in that country among a class of engineers that are careful as well critical. Herre de Laval has the advantage of a suitable and unique application to his centrifugal cream separators, one of the few applications requiring a speed such as the velocity of steam jets must involve. Assuming the velocity issue to be 48,000 feet per minute, for pressures of 80 to 100 pounds per inch, and the velocity of the wheels to be one-half this much, it calls for a speed of 8000 revolutions per minute for wheels 12 inches in diameter, which does not, however, exceed the tensile strength of the best material, and does not go beyond where very careful bearings can be maintained under light pressure. Structural difficulties must, however, for a long time remain an impediment to engines driven in this manner.

U. S. Patent No. 473,725, April 26, 1892.

E. H. BOOTH — STONE OR ORE CRUSHING MACHINE.

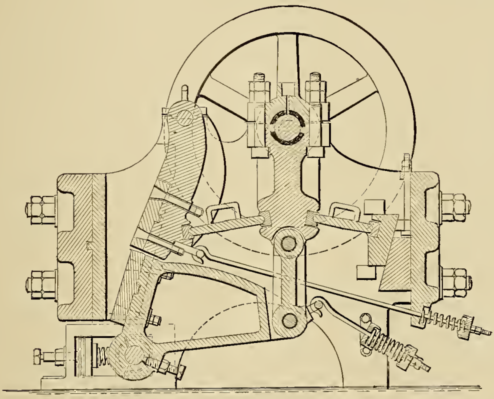
This invention, by Mr. Edgar Booth, of San Francisco, is the first considerable departure for a long time in the class of machines to which it belongs, introducing, as it does, something in the way of functions, and a great deal in what may be called the operating conditions.

The machines belong to the reciprocating-jaw kind, and are dual in so far as the jaws, but single in all other respects, and for the extent of change from common practice have but few added parts.

The following from Mr. Booth's patent specification sets forth in a brief manner the nature of his invention :

* * * "My invention is to attain nearly continuous action of the machine by reason of the alternating motion of the two jaws, and thus avoid in a great degree the strains such machines are subjected to when their work is done during one-half only of each revolution of the driving shaft, also the unequal wear on the principal working parts caused thereby, and thus the strains in my improved machines for a given work being approximately only one-half as much at any instant of time as when such machines are single-acting, or have only one reciprocating jaw."

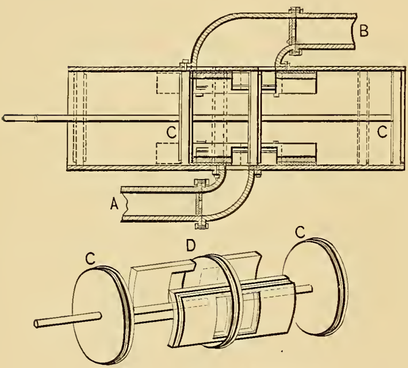
As will be seen in the drawing there are two separate jaws, the material to be crushed being acted on by the jaws



NO. 473,752. ORE CRUSHING MACHINE.

successively, both being adjustable so the work may, as nearly as possible, be divided between the two jaws and also between the half revolutions of the eccentric shaft. In this manner the weight of the fly wheels can be reduced to one-half as much, so also various other proportions required in machines that act only once to each revolution of the main shaft.

Reciprocating crushing machines seem anomalous in their capacity. At first thought one would suppose that Cornish rollers would crush stone or ore at a rate as rapid as their circumferential velocity exceeds the movement of the jaws of a reciprocating machine, or as the sum of the movement in the two



NO. 475,296. PUMPING APPARATUS.

cases. This is indeed a common opinion in the matter, but as far from correct in theory as it is in results. The relative crushing or working movement in the two cases is vastly in favor of the rollers, if we consider only the peripheral velocity, but the "working" faces of the rollers, and the only portion of their surface producing any effect, is from their centre up to a point where the material will slide back. This is only a narrow strip of the face, not more than an eighth of the perimeter, and even this must be computed by its angular approach instead of circumferential movement; in other words, the effective movement is in the approach of the faces of the rollers toward each other. For this reason we find that reciprocating machines are most common and successful, although, of late years a good deal has been gained in rotary-crushing machines by internal rolling, it may be called. That is, by means of a roller or "muller," set eccentrically within a shell or cylinder. The Gates' crushing machine is an example of this class.

U. S. Patent No. 475,296, May 4, 1892.

CHAMBERLAIN—PUMPS.

This invention is an ingenious modification of pumping apparatus, worthy of study, if for nothing else, but to show the possibilities, or want of limitation, in hydraulic apparatus. The student in mechanics and physics sets out usually with an impression that the movement of fluids, and their reactions, is but a simple branch among many others, and that a few theorems cover the field, but as he goes on he meets a world of mechanical contrivances and endless phenomena that will cause despair.

Mr. James R. Maxwell of Cincinnati, Ohio, one of our most eminent hydraulic engineers, who, after vain attempts to deal with electrical science twenty-five years before its time, went into hydraulics, as we would say, with an impression that he would, in the future, have something tangible and easy to deal with.

It was about the time that Mr. George Shields of Cincinnati, Ohio, had constructed the great Cornish bull pumping engine, in the water works there, the largest example in this country at the time. This engine caused much trouble. The steam valves persistently refused to perform their functions when moved by tappets, and Mr. Shields had to add an auxiliary steam cylinder to move them. The pump valves showed strong desire to "knock their brains out," as Mr. Maxwell called it. The rising mains and air vessels would split open in a mysterious way, and there was a disposition to chaos all around.

Mr. Shields died during the difficulty, and Mr. Maxwell was called in as consulting engineer to the water works. Then began a kind of evolution. The new business that was to have gone on

in quietness and comfort took on a garb of complexity that exceeded even electric phenomena. Mr. Maxwell, after some very hard study, proceeded to put in double-beat valves, each about the size of a driving-bell ; overhauled, reconstructed, and finally set the great "bull" engine at work, so it has gone on in an orderly way for twenty years or more.

This divergence is to say that among the arts that perplex and bother mankind hydraulics has a first place. The ram of Montgolfier, for one example, has been a sad destroyer of human conceit. It operates when not expected to, and refuses when every condition is supposed to be favorable. Its "regurgitation" is a mystery, or at least has never been analyzed in a rational way. Efficiency is a mythical quantity, and to "cap all" Mr. Pearsall of London, some years ago, eliminated the "ram" element from these machines, closing the valves gradually, and altogether independent of the driving water.

We might go on to mention "water ram," the abnormal diagrams found in Riedler's *Versuche aus Pumpen*, and, indeed, in all pumps ; the problem of forces in turbine water wheels, with much more, but it is unnecessary. Any one attempting to deal with the movement of fluids as it occurs in the practical arts will find themselves confronted at every turn with the unexpected.

Returning to Mr. Chamberlain's pump, it deserves at least the distinction of divergence from practice. Fig. 1 is a longitudinal section, and Fig. 2 a perspective view of the moving parts. The pump barrel is open at each end with a discharge pipe *A* at the bottom, and an inlet pipe *B* at the top, situated in the middle of the cylinder, or between the working pistons *C C*. Between these pistons, and sliding freely on the piston rod, is another piston or diaphragm *D*, having extending plates at each side to overlap, cover and uncover, the ports around the central part of the cylinder, and connecting with the pipes *A* and *B*. This is sufficient explanation from which to work out the problem of operation. At least is so for anyone acquainted with pumps. The system, as shown here, is for double action, but it is applicable to the single-acting kind as well.

As most of this chapter is discussion, another one will be made to point out an "anomala." The student in hydraulics is taught to compute the discharge of single-acting pumps either by set rules, such as "divide the square of the diameter by 25, and multiply by feet of stroke one way, or by computing displacement and multiplying revolutions or half strokes." This seems simple enough, and is theoretically true, but is not truth, not near the truth, unless the length and diameter of suction and discharge pipes are taken into account, and also the rate of movement. Under certain conditions, and these very common ones, the water if measured will show quantity far beyond the computed result, because the flow will be continuous, or nearly so, the pump piston acting as an "accelerating" agent to maintain the flow, the same as the oars of a boatman act in respect to a boat's movement through the water.

U. S. Patent No. 477,921, June 28, 1891.

J. M. ANDERSON—ENGINE.

This invention has for its object, where triple engines are employed at sea, the conversion of the low pressure or large cylinder to a water pump to be driven by the other two cylinders, so as to employ the propelling power to clear a ship of water in case of such requirement.

To do this the large cylinder is provided with a set of water valves, for single action, one leg of the main frame being converted to a suction pipe with a bilge inlet to the main frame beneath where the leg is bolted down. No drawings are required to explain the invention, which, if it has any practical value, could be carried out in various ways. It seems, however, to be a mere "idea," and to have no value compared with the employment of an ejector apparatus fed from the boilers direct.

The question of efficiency does not play much of a part in such emergencies as demand added pumping capacity, besides apparatus of the kind for pumping salt bilge water could not be relied

upon when used only at long and uncertain intervals.

The main purpose of mentioning this invention is to suggest that, in all cases, the fascination of an "idea" must be guarded against, and the invention, whatever it is, should be set up as an equation or an account, with all objections on one side and all advantages on the other side. If this is done, and the footings compared, the chances of survival will appear. It, of course, requires consummate knowledge of an art, and that is corelative thereto, in order to arrive at the various quantities to be entered in such an account, but the fact is that useful inventions generally emanate from people with such qualifications.

British Patent No. 10,923—1891.

TYLER AND DE VESIANI—DRILLING SQUARE HOLES.

This is at least the second patent granted in England for machines to "drill square holes" in metal, and a company has been formed to operate with the invention described in the first patent. The idea, to so call it, is novel, and the machines are ingenious, but one is puzzled to know what square holes are for in machine fitting.

In a tolerably long experience in that kind of industry, covering a great variety of work, square holes were not met with, at least not to any extent warranting the employment of a special machine to make them. Oblong holes were more common, but even these are mostly of a kind that could not be drilled or cut with a tool such as described in the patents. In connecting rods with strap joints and mortises, which make up the greater part of rectangular holes in common practice, we imagine that a cottering machine with shanks or stems as large as the whole will admit, are as nearly perfect as any implement that can be invented for cold processes.

There must be in shank-guided cutting tools a want of precision, or a difficulty in adjustment, which is much the same thing, hence in most cases, where square or rectangular holes are required, "drafts" are preferable. These make exact work, and when "pulled," instead of "pushed," can be employed of large size. At the Enfeld Arsenal, in England, drifts about one by three inches, and two feet or more in length, were employed twenty years ago in finishing the breech frame of rifles. The tools were submerged when drawn through.

For exterior work where the size of stems or shanks for tools is not limited these square-drilling machines may have useful functions, but when we consider that this class of work is very limited in quantity if we do not include screw nuts, and even these do not require finishing on the sides, except in few cases. Well-made, cold-pressed nuts, finished on the ends only and case hardened all over, are good enough for nearly all purposes where planed nuts are employed, but, this aside, no square-drilling machine can compare with a good nut planing or milling machine for finishing screw nuts.

In wood working, machines to make square holes are essential, because the ruling form is rectangular. In metal work the ruling form is cylindrical, and nearly all holes are round. We are strongly inclined to the opinion that these square-drilling machines for metal are "faddish," as our English friends would say—good for exhibition purposes where practical men are a scarce minority, hence we do not reproduce the drawings.

(*To be continued.*)

SOME POINTS IN THE PHILOSOPHY OF THE STEAMSHIP.

By Prof. W. F. Durand, Principal; Graduate School of Marine Engineering and Naval Architecture, Cornell University.

SWIFTLY and surely does the modern steamship carry its precious human freight across the waters, but few of those who go down to the sea as travelers are aware of the vast amount of study and thought embodied in the noble vessels which bear them. In the belief that a popular statement of some of the principles controlling the behavior of a ship may prove of interest to the general reader, the following article is prepared :

In the first place we must not forget what it is that makes the ship float instead of sink, notwithstanding the fact that she is usually built of steel and other materials mostly heavier than water. The first and great problem, the solution of which made the modern steamship possible, was therefore that of making a body float, though of material heavier than water. Long before the days of metal ships, however, Archimedes discovered the principle which gives the solution to this problem, and thereby laid the chief corner stone of the modern science of naval architecture.

The principle is, of course, that a body immersed in a fluid loses in apparent weight by an amount equal to the weight of the fluid displaced. It is apparent, therefore, that if by any means the weight of the displaced water can be made to equal that of the body itself, the apparent weight will vanish and the body will float supported by this buoyant action of the fluid. The problem becomes, therefore, to make the displaced fluid large, relative to the weight of the displacing body—so large in fact, that before the body shall have become completely immersed, it will have displaced an amount of water equal in weight to itself, and will therefore remain supported at that point, as stated above. The obvious means is to make the body hollow, and moreover, the thinner the shell, or what comes to the same thing, the larger the size, for a given weight of material, the more water will the body displace when immersed to a given depth, or *vice versa*, the less the depth of immersion required for a given weight. But evidently our ship must be able to carry within, something besides a hole, else its value as a freight and passenger carrying investment will not be great. We need, therefore, to be able to fill the hole again as much as possible, first with engines, boilers and various permanent fittings and fixtures ; second, with freight and passengers. As we begin in this adding of weight, the ship will sink lower and lower, always maintaining the exact equality of total weight to weight of displaced water. Evidently we must stop before the ship is submerged, practically a long way before this point is reached. Still the variations in draught of the Atlantic liners may reach six or seven feet, representing on some of the largest a variation of four or five thousand tons of dead weight. The average individual, as he boards his steamer, may remember that his presence will bring the ship nearer the bottom of the ocean by about one thousandth of an inch, an amount he will hardly notice as he steps on board.

We may remember first, then, that the weight of the ship and everything on board is at all times equal to the weight of the displaced water. This weight is called the displacement, so that the statement that a ship has a displacement of five thousand tons for example, means simply that her weight with everything on board is just five thousand long or English tons, this being the unit always used in measuring the displacement of ships.

Soon after our supposed passenger has taken up his quarters on board, found his stateroom and made the acquaintance of the steward, a ponderous throbbing begins in the vast and unknown regions below, and the ship moves. This quality of mobility is quite as important to the ship as that of carrying capacity. Whence comes it? For every motion there must be two things, a permission and a moving agent. The permission we find in the yielding nature of the medium, suffering the ship to glide through it, moving aside as she approaches, and closing in again as she passes by. To find the immediate *agent* we must go on deck and look over the stern. There we see a wake of foaming, seething water, moving away from the ship somewhat more rapidly than the water on either side. This water has been acted on by the screw or propeller, and set into motion sternward relative to the surrounding water, or relative to its condition before the propeller acted on it. This is an extremely important point, and to enforce it we may say in another way, that it is the particular business of the propeller to lay hold of water and give it a sternward velocity. But to change the velocity of a body, the action of a force is required, and this force acts equally in two directions, as an action and as a reaction. The action is on the water, and it is set in motion astern. The reaction is forward on the propeller, and this push or thrust, as it is called, is transmitted by the shaft to the ship, and thus forces her forward through the water. This matter is so important that we will illustrate it again as follows: Imagine a smooth table or other horizontal plane surface of indefinite extent, with a pair of rails running along it. On the rails let us place a platform car. The car is free to move along the rails, but such motion once set up, we may suppose it resisted by friction or some other steady resistance. Now strew the table thickly with little balls, and suppose them so truly round and hard and the table so smooth and hard that the frictional resistance to their motion may be neglected. Next, suppose a person on the car with a paddle with which he can act on the balls. He reaches over and pushes them in a direction opposite to that in which he wishes to go, taking care not to touch the table with his paddle; or, if he does, we may consider that both are so smooth that he can gain no frictional hold for a push. He has then simply the balls to act upon; but to set them in motion requires a force, which will react on him and through him on the car, thus overcoming the resistance and maintaining its motion. The yielding of the balls is an absolute necessity to the possibility of his motion. Suppose, secondly, instead of the smooth table and the balls a rough table, and a sharp pike staff instead of a paddle. With the latter he obtains a firm hold of the table—a stationary object—pushes in one direction and the car moves in the other, the final result being the same in both cases. The difference between the principles involved, however, is evident at a glance. In the former, which is, of course, similar to the case of the ship, the very condition of motion was that the body against which he pushes should yield, that being the only way in which the reactionary force can be called into existence. In the latter it is the resistant qualities of the table which prevent yielding or the slipping of the pike through it, and which therefore make motion possible.

The yielding of the medium acted on is a general necessity in all cases similar to the first above, and we find it therefore equally true and equally general for all kinds of propulsion whether in air or water. The birds of the air, the fish and other inhabitants of the deep, as well as the ships which furrow

its surface, all make use of the same principle. It is true moreover, that it requires work to set up this motion in the medium; that is, that of the total work available for propulsion, a part must be used to give to the water the motion astern. In a certain sense this work may be called a loss, but it is a loss inherent in the very nature of the problem, and one that can be only reduced to a minimum; not completely avoided.

We have thus seen how it is that the water is made to furnish a thrust through the means of the propeller, but at the same time it presents a resistance to the motion of the ship through it, to which the thrust must be equal. We have thus a system of balanced forces, and so long as this condition is fulfilled, the motion of the ship will be uniform. But, in the meantime, what has the engine to do with all this? In reply, we may say that it is the business of the engine to turn the propeller. It exists solely for that purpose and is simply, in fact, one link in the chain of elements wherewith the energy stored up in the coal is finally transformed into the useful work of pushing the ship through the water.

So then as we look off astern, we remember that the wake water stretching away in the distance is the visible sign of the agent which constantly, as we look, is urging us forward.

Following after the question of motion in general, it seems natural to inquire just what limits or controls the speed of the ship when a given engine power is constantly supplied. Of course it is the resistance, but in what way does this resistance act, and how is its action related to varying speeds?

Any measurably complete answer to these questions would be far aside from our present purpose, but we may say, in a general way, that most of the resistance comes from two causes, fluid friction and the production of waves. This fluid friction has the peculiarity of increasing as the square of the speed. That is if we double the speed we multiply the frictional resistance by four. If we triple the speed it is multiplied by nine, and similarly for other variations. If an observer will closely watch the water as it glides by the ship, he will see, close up to the ship's side, little eddies and whirls having, in addition to their whirling motion, a relatively slow motion of translation along with the ship. They will appear to go backward, but less rapidly than the outside water, so that really they are moving forward with the ship. These eddies and whirls are formed of the water which has been taken hold of by the ship and rubbed, and thereby thrown into this vortical motion. This skin of troubled water is then the outward mani-

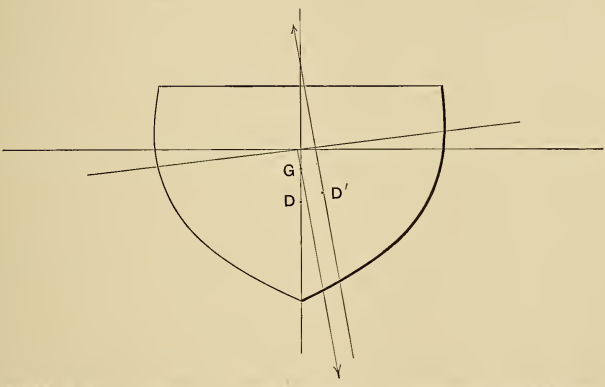


FIG. I.—G, CENTRE OF GRAVITY OF SHIP. D, CENTRE OF GRAVITY OF SUBMERGED FIGURE WHEN UPRIGHT. D′, CENTRE OF GRAVITY OF SUBMERGED FIGURE WHEN HEELED.

festation of what is called fluid friction, the cause of most of the resistance to the motion of the ship.

Again, if an attentive observer will note in moderately smooth water the system of waves formed by the ship as she advances through it, he will readily see another potent cause of the resistance of the ship. There may be seen spreading off from either side of the bow, in an oblique direction, a system of little detached or independent waves. Each of these was formed by the reaction between the bow of the ship and the water through which it was forced. series of waves, long and low, having their crest lines at right angles to the direction of the ship. They are not so readily observed, however, and any extended description is not necessary to our purpose. It will be sufficient to say that these waves follow along with the ship, and their location relative to the ship has much to do with her resistance. At moderate speeds the resistance due to these various systems of waves is not great—perhaps from ten to fifteen per cent. of the whole. As the speed is much increased, however, the resistance due to them assumes

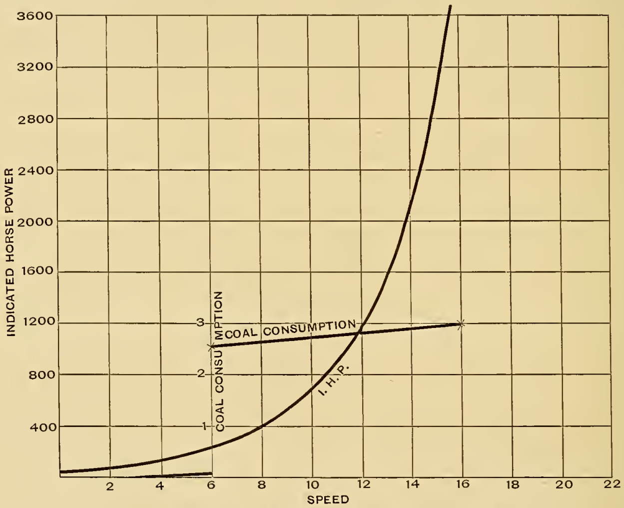


FIG. 2.—DIAGRAM SHOWING RELATION OF SPEED TO COAL CONSUMPTION.
SCALE.—I. H. P., 400 = 1 DIVISION. COAL CONSUMPTION, 1 LB. OF COAL PER I. H. P. PER HOUR = 1 DIVISION.

Their formation presents so much additional resistance, and calls for the expenditure of so much additional work, and, therefore, for the development of so much extra power in the engine. We may, therefore, in a figurative way, consider each one of those little waves as carrying away in itself a lump of coal from the ship's bunkers. Again, branching off from the stern, in similar oblique directions may be seen another series of somewhat smaller waves, but each as before carrying away coal from the bunkers. There is still another great prominence, and is the chief cause of the sudden and great relative increase after the speed has passed a certain value. This value depends principally on the length of the ship, and roughly may be taken in knots per hour at not far from the square root of the length in feet.

If it be assumed in general that the resistance varies as the square of the speed, then it follows that the power will vary as the cube of the speed. That is, if we double the speed we shall have a four-fold resistance to overcome through

a two-fold distance per hour, requiring therefore an eight-fold work, and similarly for other speed variations? At relatively high speeds the required power increases even faster than this, but even at this rate the increase is so rapid that at high speeds the cost of each additional knot seems out of all proportion to the slight increase in speed. Thus, for example, if a vessel of say 8000 tons is content to go 18 knots per hour, she would require perhaps 10,000 horse-power, or an average of 555 per knot. If, however, she wishes to go 19 knots, there will be required, not an additional 555, but instead some 1800, making a total of 11,800, while 20 knots will require not 1110 more, but instead some 3800, making a total of 13,800. On the contrary, if she were content to go at 15 knots, a modest 5800 would suffice. It is thus seen that an increase in speed of from 15 to 19 knots would require a double horse-power while the time of a trip would be about eighty per cent. of its former length. The coal bunker capacity must be, therefore, some 1.6 times as great as before, while the machinery will be of nearly double weight, to say nothing of increase in personal and general running expenses, and a decreased freight capacity, by no means counterbalanced by the slightly quicker trip. Should we then be surprised that fast ocean steamers are expensive luxuries, and that those who use them should be expected to pay accordingly? As to the future development of speed, it is not easy to see what is to come; but for one point we may feel certain, that as fast as the public will pay for it, speed will increase up to some point at present impossible to state.

Another interesting result of the relations between speed and coal consumption is, that the slower a steamer goes, the farther can she go on a given amount of coal. This law holds down to a certain point determined by considerations unnecessary to discuss here, but usually less than half maximum speed. Thus, if the vessel supposed above steams at a maximum of 19 knots, starting with, let us say 1800 tons, she will be able to go some 3000 miles, while at 15 knots she could go perhaps 5000 and at 10 knots about 12,000.

But let us turn to other matters. After a time, in the ordinary course of events, the ship will meet a storm, the waves will rise and the ship will begin to roll and pitch. There are various phenomena usually connected with these motions, but it is only our present purpose to discuss some points connected with rolling. To state the general problem as a question, we may ask: why should the ship roll first to one side and then to the other, instead of rolling all the way over in one direction? The rolling of a ship is analogous to the oscillation of a pendulum, or a rigid body supported on an axis, and we shall endeavor to show that the ship does not roll all the way over for the same reason that such a rigid body does not turn all the way around on its axis, when slightly displaced from its position of rest. The position of equilibrium for the latter is with its centre of gravity directly under the point of support. So with a ship, the position of equilibrium is with her centre of gravity directly under the point of support. But what is the point of support in the case of a ship? Here the analogy seems to fail. Not so, however, as a little thought will show. We will first remember that the ship presses down on the water with a force equal to her weight, and that reciprocally the water presses up on the ship with an equal force. This latter is the supporting force, and is distributed all over the ship's bottom. Now, this distributed force may be replaced by an equal single force, acting upward through the centre of gravity of the displaced volume. To prove this last statement, we note that the ship and the surrounding water may be considered as two bodies in equilibrium. Suppose now that the ship could be lifted out of the water while the latter remains fixed, thus leaving for a moment a cavity just the shape and size of the under water portion of the ship. Next, let a thin bag be fitted to the inside of the cavity and filled with water. Its weight will equal that of the ship, because it is simply the

displaced water, to which the ship is always equal in weight. Now, with reference to the outside water, it is indifferent whether the cavity is filled with the ship or with the water-filled bag. In either case the two will be in equilibrium. In the latter case the weight of the water will act down through its centre of gravity. Therefore, the supporting force which, considered as single, must be exactly opposed to the weight, must act upward through the same point. But if the upward supporting force so acts in relation to the water-filled bag, it will act in exactly the same way, and through exactly the same point in the case of the ship. This point is called the centre of displacement or centre of buoyancy. As the ship rolls back and forth the point changes position relative to it, but is always the centre of gravity of the volume of displaced water, and is always the point through which the supporting force, considered as single, has its line of action.

Now, to return to the case of a rigid body supported on an axis above its centre of gravity. The point of support is here fixed, but from our standpoint that is not its chief characteristic. We note rather that it is the point through which the supporting force always passes. Therefore, if we can find such a point relative to the ship, it may be considered as the point of support. Suppose, then, a ship in equilibrium with her masts vertical. The line of the supporting force is always vertical, and is now, therefore, a vertical line in the plane of the masts. Next, suppose the ship is inclined through a small angle, such as a four or five degrees on each side of the vertical. The plane of the masts and with it the original line of support being always vertical, will interest the old in some point. Suppose that this point remains the same for this small angular motion, it would evidently fulfill the condition of being the point through which the supporting force always acts, and therefore, for this small motion it would be the point of support. The ship in such an oscillation will act as though she were a rigid body supported on an axis through this point, and set to swinging upon it. It may be shown that this point of support does not remain the same, as the ship inclines to different angles. Yet, for a very small roll back and forth at any part of the whole range of motion, the supporting forces will go through practically a single point, and this point is then the point of support at that particular point of the motion. As the ship rolls back and forth over her entire range of motion, the point of support changes so that her motion is similar to that of a pendulum, whose length changes as it oscillates to and fro. The particular location of the point when the ship is upright, that is the point support for an indefinitely small motion either way from the upright position, is of great importance in the theory of the stability of ships. It is called the metacentre, or sometimes the upright or true metacentre to distinguish it from other locations of the same point. Now, in the case of a rigid body, it is plain that if the point of support is below the centre of gravity the body will be in what is called unstable equilibrium ; that is, it will topple over on the application of the least force. So with a ship, if the metacentre is below the centre of gravity, it will be in unstable equilibrium, and will turn over, perhaps not all the way, but at least to some point where the metacentre is above or at the centre of gravity. To answer our first question then, as to why the ship does not turn all the way over, we may say that it is for the same reason that a pendulum when slightly disturbed does not go all the way around, but returns rather to its position of equilibrium ; and further, that the analogy with the pendulum is true, because the ship has been so formed and her weights so distributed that her metacentre is some two or three feet above the centre of gravity.

But we can gain still further light from the analogy of the pendulum or suspended body ; for the greater the distance from the axis to the centre of gravity, the greater the return force for a given angle of inclination, and within certain limits, the quicker the oscillation. So with a ship ; the greater the

distance from the centre of gravity to the metacentre, the greater the return force for a given roll, and the quicker the oscillation. This in general would seem to be desirable, since it means a less likelihood of the overturn of the ship by a sudden squall or other like disturbance. From this point of view it is desirable, but the quicker oscillation which accompanies the large return force makes the ship livelier in a seaway, and her motion is apt to be sharp and jerky. Furthermore, the possession of such large return force means, of course, that in still water the ship will tend strongly to maintain herself upright with reference to the still water ; but this very quality carries with it the strong tendency to maintain herself with her masts in general at right angles to the wave surface when in troubled water. Following this inclination, she will tend to make a double oscillation for every wave. Such a ship is denominated "stiff." On the contrary, if the return force is small, there will be correspondingly small tendency in still water to seek an upright position if displaced from it, and in consequence small tendency to depart from its general upright position when on a wave slope and under the influence of the wave. That is, there will be small tendency for the ship to place herself with her masts at right angles to the wave slope, and consequently small tendency for the ship to oscillate in synchronism with the wave. Such a ship will, in some ways, be less affected by waves than the stiff ship, and will therefore be somewhat easier in a seaway. There is, however, a limit to this desirable sluggishness, for if carried far the ship becomes like a log, liable to roll to an excessive degree under the influence of the wind or under certain cumulative actions of the waves, and liable to be swept by the waves instead of riding over them. It follows that for steamers—that is, for vessels in which the disturbing tendency comes principally from the waves—the stability is allowably somewhat less in relative amount than for sailing ships, in which the distributing force comes principally from the wind.

Another influence of waves upon a ship may also be occasionally observed. As was noted above, all ships exhibit a greater or less tendency to oscillate, keeping time with the waves. Now, if it so happens that the successive wave influences are so timed as to correspond to the natural period in which the ship oscillates, a relatively small sea may give rise to a very considerable amount of motion in the ship. The case is analagous to the vibrations which may be set up in a bridge by a number of properly timed, relatively small impulses, as from the passage of a trotting horse or a number of men keeping step. In fact, if the agreement in the case of the ship is approximately exact, and if her natural period as she rolls does not change due to a change in metacentre, the frictional and other like resistances which she meets alone save her from turning over. In this particular the ship of small stability has a certain advantage, for her period of roll will be long—so long that the wave impulses in all ordinary cases will be too rapid to correspond to her natural period, and she will therefore be more apt to escape this cumulative effect. It sometimes happens, however, that a ship of very long natural period, in steaming in a certain direction relative to the waves, will so lengthen or change their period relative to herself as to bring it into correspondence with her natural period of roll. It is for this reason that a ship will occasionally develop an apparently excessive amount of motion under the influence of waves of relatively small size.

These problems are but a few of the many that have had to receive due consideration in the design and construction of the ocean steamer. Like all other good things in this world, she is a bundle of compromises, and the great skill in design arises in knowing just what weight to give to the various conflicting considerations, and to so adjust and correlate them that there may result the best combination of good qualities, and each in the proper degree. No two opinions will be in entire accord on such points, and so it may be truth-

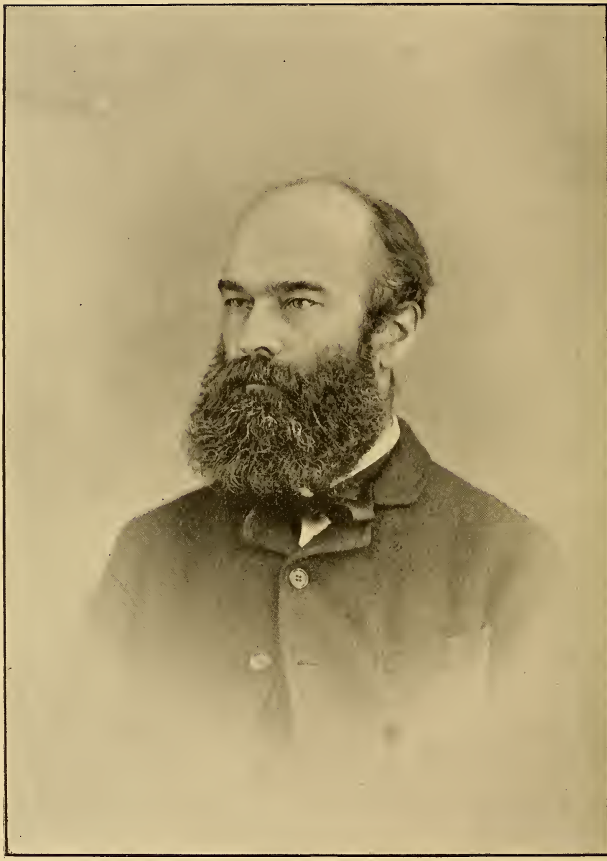
fully said that in detail there is no absolute ideal ship. Each designer has his own ideal, based on his own opinion of the just proportion of desirable qualities. Another reason for the great difference sometimes found in different vessels intended for the same general purpose lies in the fact that to the main questions arising in ship design there is no direct method of solution.

Required a ship of given size, there is no telling what her resistance will be until her form is specified, and even then it can only be approximated to. Then, having given the form, there is no direct method of designing a propeller which on first trial will be certain to give the best results. The processes are largely tentative in character, and the results are always subject to correction from the indications of actual trial. It may seem strange that there should be such an element of uncertainty in such matters, rather than some direct method of formula which will give immediately the desired results.

This is a feature peculiar to marine design, and is largely due to the fact that the whole behavior of a body in the water, whether it be ship or propeller blade, is dependent on its external form, as well as on its volume, smoothness and other characteristics. These latter elements can be calculated or expressed as a definite single quality. Form, however, depends on an infinite number of dimensions or measures, and its varieties are therefore infinite in number. The surfaces which give the form to ships are not such as can be expressed directly in mathematical symbols, no more then can the form which results be brought under mathematical representation. It results that any attempt to take account mathematically of the complete form of a ship or other immersed body is impossible in the present condition of mathematical science. But unless the form can be taken account of—that is, unless it can have its proper representation in the mathematical formula, the latter will fail to represent the controlling conditions, and therefore its results will be incorrect, or at best incomplete. Those who are somewhat acquainted with mathematical methods will readily understand the difficulty by proposing to take account in a mathematical formula of the influence of a little depression at one point or swelling at another.

If there is, then, no direct and royal road to the solution of such questions, it is evident that different workers, under different circumstances, and guided by varying practical results, will be led to different solutions of the same problem.

The wonder is not that there is differerence of opinion and practice in ship design, but rather that the differences are so small. Indeed, the substantial unity of practice goes far to show that, taking all things into account, the present forms cannot be far from those best adapted to the circumstances under which they are used, and that no very great improvement is to be expected in the matter of form alone. It would seem, then, as though the next sweeping improvement would have to come in the fundamental conditions of the problem rather than in any better solution of the problem as adapted to present conditions. As to how soon or in what way this grand change is to come, time alone can unfold.



JOHN KENNEDY, PRESIDENT CANADIAN SOCIETY CIVIL ENGINEERS.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

By F. Houghton.

IN writing a historical sketch of the Canadian Society of Civil Engineers, I will begin by quoting from the address of the first president, Mr. Thomas C. Keefer: "The association of civil engineers for mutual improvement is the outcome of the present century, the English Institution having been established in 1818 and incorporated in 1828, and the American Society in 1852. There was a society of engineers founded by Smeaton in 1771, but it was rather a social club than a scientific association. The English institution has increased during the Queen's reign from 238 members of all classes to 5400, and in revenue from £713 to over £21,000." It is not known exactly when the first agitation for the formation of a Canadian society of engineers began, though it was a subject of discussion among engineers long before any decided action was taken.

The Canadian Institute incorporated in 1851 was formed "for promoting surveying, engineering and architecture."

The probability is that the agitation dates from the formation of the land surveyors into a close corporation. Engineers out of employment were prohibited from practicing as land surveyors without first undergoing an apprenticeship, as well as passing an examination. On the other hand, land surveyors, whether competent or not, were at liberty to practice as civil engineers. It was only natural, therefore, that it should give rise to a feeling that not only was a standard of qualification required, but that the profession should have the same advantages as land surveyors, and be restricted to those only who were qualified by law. But, whenever this was proposed, for some reason or other the general feeling seemed to be against it. "This is probably due," says Mr. Keefer in his address, "to the knowledge that the great Institution organized at the Randall Coffee House in Fleet street, on the 2d January, 1818, by William Maudslay and James Askwith, of which Telford was the first president, and which is the mother of us all, had proved a magnificent success without protection, as well as to the reflection that the founders of the profession in Great Britain and the United States were born engineers,—sought only a free field and asked no favors." The reason in this first instance, that, because an unprotected society was formed nearly a century ago which proved a success, a society formed to-day on the same footing should be equally successful, when one takes into consideration the amazing change in this century, seems to me to be no reason at all. The true reason was probably this: that young engineers lacked a head, a moving spirit, and properly concerted action, while the older members of the profession were deriving a comfortable income from their work, and were both too lazy and too selfish to bestir themselves in the matter at all. However, some one had stirred up the agitation in Canada, and as it was a right and proper thing to do, and exactly what the profession wanted, something was bound to come of it, and something did come of it.

In May, 1880, Mr. E. W. Plunkett, now a member of the society, obtained a list of engineers, and issued a circular signed "X. Y." setting forth the necessity and advantages of organization. "At present," the circular said, "the engineering profession in Canada has no entity or representative body, and consequently it does not enjoy the essentials of healthy professional life—a standard of qualification, an active

progress in working membership, a professional code, an opportunity for encouraging and cultivating engineering talent, and generally the preservation and promotion of the interests of the profession.'' He did not propose a close corporation, but thought the charter should resemble as closely as possible that of the Institution of Engineers in England. In all probability it was Mr. Plunkett's circular that suggested a bill being introduced into the Ontario Legislature in February, 1881. This bill was entitled "An Act Respecting

THE READING ROOM.

Civil Engineers,'' and uncommonly disrespectful it was to the opinion of many. The bill was not founded upon a petition signed by anybody, but the introduction states that it is expedient, with a view to the proper and efficient qualfication of civil engineers in the province of Ontario, that the same should be regulated by statute. It divided the profession into departments or branches, and engineers into grades or classes, and constituted fourteen engineers by name as civil engineers in grade A within the meaning of the act. All the rest were left out until a council of ten, appointed by the Crown, had examined and admitted them. The Commissioner of Public Works for Ontario was to be *ex-officio* chairman of the board of ten examiners, and, as the quorum for the examination of candidates was only three, this gentleman, not necessarily an engineer or even a land surveyor, but most probably a lawyer, doctor, merchant, or farmer, could have decided the fate of the candidate. For any other business of the board the quorum was to be six. Students, before being indentured, were to pass a preliminary examination, and no one was to receive a commission as civil engineer until he had passed a satisfactory examination before the triumvirate quorum in the subjects enumerated in a schedule printed in the act, which schedule would have served as a full index for an encyclopedia of civil engineering. Members of the Institution of Civil Engineers were by this bill made eligible for final examination by the votes of at least three lawfully constituted Canadian engineers.

THE HOME OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The board was empowered to charge annual fees for membership, to divide engineering into branches, and to grant a diploma entitling candidates to practice in those branches only upon which they had gone up for examination; also to classify engineers into grades A, B, C, D. An A1 man who could take the whole 28 engineering subjects described in the index was to rank as chief engineer. B was to pass in more than one branch to be chief engineer only in the branches for which he had passed and been commissioned. C was a one-branch man, and his diploma made him a simple engineer in that only. D held a second-class diploma, and ranked as assistant engineer.

The board could fix the fees to which engineers were entitled in the absence of agreement, suspend or dismiss from practice any engineer for cause; but the Court of Appeals of Ontario could quash their decision. They could also examine candidates for admission under oath "as to his practice with regard to his instruments." All engineers, except the original fourteen Parliamentary ones, on passing their final examination, were to give a bond of $5000 to Her Majesty, supported by two securities, and take an oath of office.

"All those who had not mastered the A B C, as well as D of their profession, as above defined, and come into the fold before 1st June, 1881, were prohibited from practicing as civil engineers under a penalty of $100 for each offense, one-half to go to the informer."

But, as Mr. Keefer goes on to say, "there is a substantial difference between imposing a fine and collecting one," and it is altogether likely, such being the case, that the business of informing would not have been exactly a lucrative one, especially as the bill did not provide for imprisonment upon non-payment of the fine.

The final clauses of the bill exhibited some practical features, providing that examiners should receive $5 per day, including living and traveling expenses, this payment to be made from the consolidated fund of the province, "but for the main items of the estimate the provincial treasury was the only reliable source of supply." But the bill never reached a committee, being repudiated by the majority of the fourteen engineers named in it, who had never petitioned for it and were doubtless ignorant of its inception. It was fortunate that they did so, however; for, had they done otherwise, in all likelihood the government would have withdrawn the clause aimed at the provincial treasury, which would very likely have proved fatal.

Mr. Keefer, in his address, gives the above details of the bill in order that it may be contrasted with the simple provisions of the society's present charter, "which, while giving us a better legal status, enables us to pass regulations and by-laws for the direction and management of all the affairs of the society."

Evidently the difference of opinion, as exemplified by Mr. Plunkett's circular of 1880 and the Ontario bill of 1881, checked further effort for the time being.

In discussing the subject of this article with Mr. J. M. Shanley, M.C.S.C.E., of this city (Montreal), he informed me that Mr. Sanford Fleming, of Ottawa, while chief engineer of the C. P. R. surveys in British Columbia for the Dominion government, made an attempt to rouse engineers to the necessity of forming a Canadian society for the protection of the profession; but the effort received a lukewarm support from his professional brethren, and, in consequence, fell through. This must have been five or six years prior to Mr. Plunkett's sending out his circular, on the failure of which, until the year 1886, nothing further was attempted.

In January of that year Mr. Alan Macdougall, whose name will be ever remembered in connection with the society as one of its first originators and ablest supporters, issued a circular over his own name, which led to the formation of this society about a year later on. In his circular he refers to Mr. Plunkett's, which he says was well responded to; but in his he proposed a close corporation, and this, for some reason or other, I am told prevented many engineers from responding, as otherwise they would, in all probability,

have done, although he invited correspondents to communicate their own views. Then he followed up his circular in a sensible and very practical manner. In February, 1886, he issued another, and called a meeting in Toronto, afterwards applying to Mr. Kennedy, now president of the society, to preside at a meeting of Montreal engineers to consider the question. This meeting was held on the 4th March, 1886, and resulted in a draft of a constitution. A similar meeting was called by Mr. Macdougall, in Ottawa, for 30th March, at which the Montreal draft was considered and amended by the Ottawa local committees. Delegates were appointed by the local committees of the three cities, Montreal, Toronto and Ottawa, and empowered to submit a constitution and elect a provisional committee, which met in Montreal on 9th December, 1886. A circular, signed by Mr. Macdougall as provincial secretary, was sent out to members of the profession on 21st December, 1886, enclosing a copy of the constitution, and notifying them that the committee would meet in Montreal on the 11th January, 1887, for the election of members, and to send out a ballot paper for the officers and council. Recipients were requested to sign a printed slip attached to the circular if they desired to become members of the society. In this way the provisional committee would know at its meeting in January who were willing to join, and thus be able to elect such members. On the 20th January, 1887, another circular was issued by the provisional committee, announcing that 188 engineers from all parts of the Dominion had responded favorably to its first circular, and requesting members to forward their fees, to meet printing expenses and cost of charter. Before a constitution could be adopted or further progress made there must be members to vote upon it, and these members could be chosen only from those who had signified their willingness to join the society. The circular invited those engineers who had joined to examine the printed list of members elected by the provisional committee, and solicit any of their professional brethren whose names did not appear to become members. Thus an additional number sent in their names in time to receive the ballot papers for the officers and council. In this way 288 members of all classes were elected by the provisional committee up to February 24, 1887, the date of the first general meeting, held in the Harbor Commissioners' building, Montreal, at which the result of the ballot papers sent out prior to this meeting was announced, the constitution adopted, and application for a charter made to the Dominion Parliament, royal sanction being obtained on the 23d June following, and then our society began its legal existence. All the preliminary proceedings up to this time were annulled by the charter, which did not set up anything previously done as law, and it became necessary that a new election and adoption of constitution should be had, which was done by submitting tickets for officers and the constitution adopted at the annual meeting to a second vote of the members.

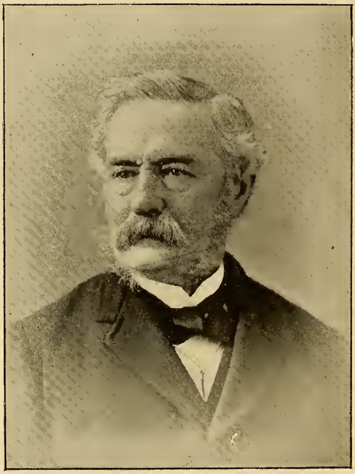
The charter was carried through Parliament by Mr. Walter Shanley, M. P., one of the vice-presidents of the society, and through his representations fees were refunded.

Up to the 24th February, 1887, 288 members of all classes were elected by the provisional, as above stated. Of this total number, 168 were members, 39 associate members, 12 associates, and 69 students. Since then the society numbers have increased to about 800 members of all classes, which the writer believes a remarkable increase for so young an organization, and promises well for the future standing of the society.

On the 25th June, 1887, the first meeting after incorporation was held, when the first president, Mr. Thomas C. Keefer, and officers were elected.

Thus far the society, it is believed, with all due modesty, may be pronounced a success. It has facilitated communication among the different members. It has placed on record engineering work peculiar to the country, which otherwise would never have come to light or been entirely lost. It has es-

tablished for Canadian engineers a headquarters. It has provided for the use of its members comfortable reading rooms, with an extensive engineering



THOS. C. KEEFER, THE FIRST PRESIDENT.

library, and it has established a regular course of meetings, which are held every alternate Thursday, where those members interested in their profession may come to discuss and read papers on subjects of professional interest.

In setting forth the aims of the society, I cannot do better than quote from its charter by-laws :

"The Canadian Society of Civil Engineers having for its objects and purposes to facilitate the acquirement and interchange of professional knowledge among its members, and more particularly to promote the acquisition of that species of knowledge which has special reference to the profession of civil engineering, and to encourage investigation in connection with all branches and departments of knowledge connected with the profession."

It is only giving them their just dues to mention the names of those gentlemen, the originators of this society, to whose support it owes its present success. They are :

Mr. P. Alexander Peterson, Mr. John Kennedy, Mr. Herbert Wallis, Mr. Percival St. George, Mr. Alan Macdougall, and Professor Henry T. Bovey.

Mr. Thomas Keefer enjoyed the well deserved honor of being elected first president of the Canadian Society of Civil Engineers. He is a native of Canada, having been born at Thorold, Ontario, and educated at the Upper Canadian College. His early experience was on the Erie and Welland canals. He was then engaged by the Ottawa River Improvement Works, under the Department of Public Works of Canada, known in those days by the title of "Board of Works." Mr. Keefer was the first to demonstrate the practicability of bridging the St. Lawrence river opposite Montreal, and it was he who in the first place located the site of the Victoria bridge. From 1852 to 1857 he

THOS. MONRO, VICE-PRESIDENT.

was chief engineer of the Montreal water works. He then built the Hamilton water works, 1857 to 1860. Afterwards he became chief engineer of the

Ottawa water works, which position he occupied for two years, from 1872 to 1874. He was also chief engineer of the ship channel between Montreal and Quebec. Mr. Keefer has had an extensive consulting practice in railway and hydraulic works for many years past. He had controlling interest in the Ottawa street railway, was engineer in charge of its construction, and its president for a number of years. He has done much towards working up the Canadian Society of Civil Engineers, and placing it on a successful footing.

Mr. John Kennedy, the president of this association, is a Canadian by birth. His first experience was under Mr. Thomas Keefer, on the Montreal water works, about the year 1856. He then became Mr. Keefer's assistant on the Hamilton water works, afterwards going into practice with him. During the time of their partnership they constructed the Toronto water works and Ottawa water works. From 1864 to 1867 he held the position of deputy city surveyor of the city of Toronto. From 1867 till 1868 he had charge of iron mining and smelting works on the Gatineau river. He next became partner in the firm of William Kennedy & Sons, mechanical engineers. On leaving this firm he went into railroad construction, and had charge of several divisions during the years 1871 and 1872 on the Wellington, Grey and Bruce Railway. On the completion of the construction of this road he became Resident Engineer of the great Western Railway system, under Mr. George Low Reid, afterwards succeeding him as the chief engineer. About the year 1877 or 1878 Mr. Kennedy was offered the important position of chief engineer of the Montreal harbor works, which included the supervising of the work on the ship channel improvements between Montreal and Quebec. This position, which necessitates indefatigable labor, vast experience and ability of a high order, Mr. Kennedy still holds. Apart from civil engineering, he has made his mark as a mechanical engineer. He holds successful patents of dredging machines now used in different parts of the United States. Besides the well-deserved honor of occupying the position of president of the Canadian Society of Civil Engineers, Mr. Kennedy for many years past has been a member of the Institution of Civil Engineers, of England.

Mr. Thomas Monro, vice-president of the Canadian Society of Civil Engineers, is an Irishman by birth, and came to Canada in 1850. He was immediately employed under Mr. Thomas C. Keefer on various surveys—Montreal and Kingston Railway, St. Lawrence bridge (now the Victoria), Montreal water works, etc.—until 1854. From 1854 to 1856 he had charge of a portion of the G. T. R. construction at Prescott. From 1857 to 1859 he was assistant engineer on the Hamilton water works, and resident engineer on the Hamilton and Port Dover Railway. From 1860 to date he has been in the service of the Canadian government as an engineer. During this period of over 32 years Mr. Monro has been engaged in some very important works, a *resume* of which is as follows: In 1863 he was appointed one of the government inspectors of railways, and in 1864 specially sent to report on the best means of supplying water to the Parliament buildings at Ottawa. In 1868–'69 he examined the east shore of Lake Huron and north shore of Lake Erie with a view to establishing harbors, and also made a partial examination of the Dawson route as a proposed means of water communication with the Northwest. In 1870–'71 he located the present New Welland canal. The next year he was appointed engineer in charge of the Welland canal enlargement. This work was subdivided, and Mr. Munro superintended the construction of the new line of canal north of Allanburg, on which all the new lift wells are situated, and remained in charge up to the end of 1888, the canal being then deepened to 14 feet. In 1889–'92 he was specially sent by the late Mr. Page to survey and report upon the question of locating a new canal between Lake St. Louis and St. Francis. After great opposition, this canal, named by Mr. Monro the "Soulanges canal," is now

in course of construction in the line recommended by him, and several important changes have been made in the plans of wells, which it is believed will

W. T. JENNINGS, VICE-PRESIDENT.

result in facilitating the passage of large vessels, and at the same time reduce the cost of the works. Mr. Monro also designed the water works at St. Catherine's and Nerriton, Ontario, and reported on systems for Simcoe, Clifton, etc. Last year he was sent by the government to report on the Manchester ship canal, and has had an extended experience in dealing with subjects connected with hydraulic engineering. He is a member of the Institution of Civil Engineers and was elected a vice-president of the Canadian Society of Civil Engineers at its last general meeting.

Mr. William T. Jennings, vice-president, is a Canadian by birth, a son of the Rev. Mr. Jennings, the well-known Presbyterian minister. He was educated in Toronto, and is now about 40 years of age. His first experience was as assistant engineer on the construction of the "Air Line," Great Western Railway. He was next employed in various capacities on the Canadian Pacific Railway surveys during the Canadian government *regime*. He then became division engineer under the government, later on holding the same position under the present company. He was appointed manager of construction for the Canadian Pacific Railway from Toronto to Windsor. In 1890 he was appointed city engineer of Toronto, but he resigned, as he objected to being taught the A B C of his profession by civic dignitaries—aldermen whose qualifications for such simple instruction were vulgarity, conceit, and an overweening confidence in their own gigantic ignorance. Mr. Jennings is now engineer in charge of the electric railway between Niagara on the lake and Niagara Falls, the line being constructed on the Canadian side. It may be interesting to note that this is the first line of its kind

P. ALEXANDER PETERSON, VICE-PRESIDENT.

in America for heavy traffic. Mr. Jennings has also a large practice as a consulting engineer.

(*To be continued.*)

ECONOMICS OF AUTOMATIC ENGINES.*

By Prof. R. H. Thurston, Director; Sibley College, Cornell University.

THE "automatic" steam engine is a form which, though a generation old, has come into very general use only within a few years, and mainly since the demands of electric lighting have been so exacting in the matter of regulation. In earlier days, a variation in speed of five per cent. or more from the main, in many applications of steam power, was perfectly admissible; and even in the most exigent of work, that of cotton mills making "fine goods," two per cent. variation was thought about the limit of practical attainment and very satisfactory. It is now considered that a range of one per cent. from the main is too great for the purposes of the electrician, and, so far has invention and improvement extended, it is possible to secure a guarantee, from makers of the latter forms of the "automatic" engine, that no variation shall take place though the load be thrown off entirely and at once completely restored; while, with some constructions, it is actually practicable to make the machine assume a higher speed with full load than with none. This is an incidental result of the attempt to meet the requirements of modern engineering; which requirements compel a complete revolution in the type of engine formerly most familiar to us.

The greater part of the machinery to be driven by these engines, as constructed by the electrician and engineer, calls for a small amount of power and a very high speed of rotation. The armatures of standard forms of dynamo-electric machines ordinarily range from speeds of 1000 to 3000 revolutions per minute, though special constructions are brought down to a fraction of these figures. The power is from ten to forty or fifty horse-power in common distributions and up to as high as 250 for the largest single dynamos; although, often, the dynamos may be so grouped that from 500 to 1500 horse-power may be taken from one engine. It is not yet possible, in all cases, to determine whether a large single engine or several smaller machines of similar aggregate power is best; but the demand for the small engine of from twenty-five to 100 horse-power is enormously great, and the manufacture of this class of engine has been immensely stimulated by the comparatively recent developments of systems of production and of distribution of electric energy. These machines are commonly of the class here denominated "automatic," are "high-speed" engines of a modern and special type, and are characterized by a "positive" valve-gear as distinguished from the older and more familiar forms of "trip cut-off" or detachable gear, with regulation by a governor which determines the point of cut-off by, usually, shifting an eccentric, as years ago employed by Hartnell and by Hoadley, and this engine is built to operate at a speed seldom less than 200 revolutions a minute, and often above 300. The positive motion, as a valve system, and the shaft-governor, are necessary consequences of the demand for high-speed or rotation and nice regulation; the latter being, in fact, a more essential matter than the former, and one which has compelled many modifications of the details of construction of the older forms of engine to secure satisfactory uniformity of motion. The characteristics and the essentials of each type are now so familiar to all that it is unnecessary for present purposes to describe them in detail. An "automatic" engine has come to be defined as one in which these methods of construction have been adopted, and

* From the Journal of the Franklin Institute.

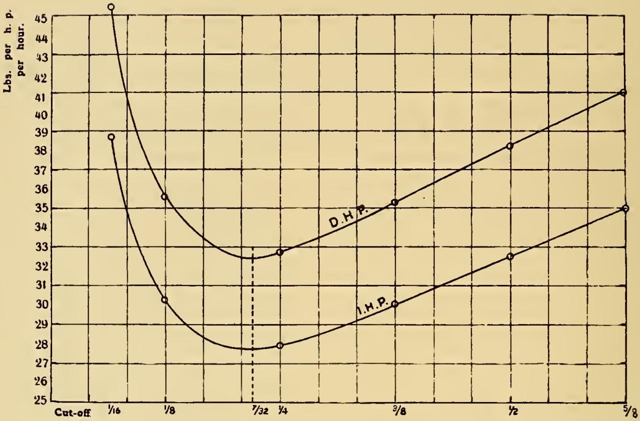


FIG. 1.—ECONOMY AT 75 LBS. PRESSURE.

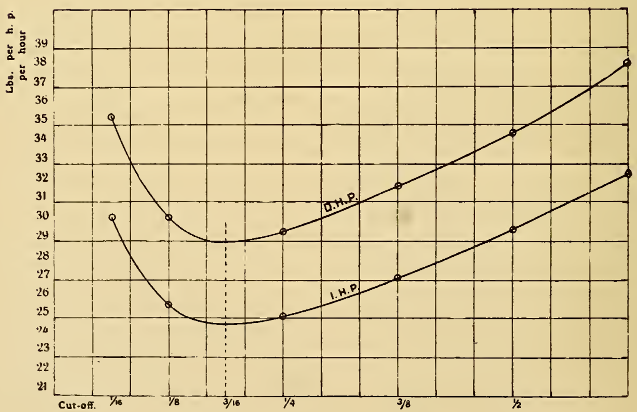


FIG. 2.—ECONOMY AT 95 LBS. PRESSURE.

which, having a positive valve-motion and firmly connected governor, adjusts its power to its load automatically through the latter. The definition logically applies quite as well to the Corliss and Greene and similar detachable systems of valve-gear; but convention seems to confine it to the later high-speed engine.

The modern automatic engine, at its high speed of rotation, brings into play the forces of inertia to an extent never observed in the older machine, and its design must usually be modified somewhat to insure smooth working by the introduction of compression and counter-balancing to a correspondingly greater extent, and with much greater care than formerly. This means increased clearances, as compared with the other type, and often heavier running parts, adjusted as to weight in the manner first practiced by Porter, as well as the long familiar counter-balancing. The Porter system gives more perfect adjustment of pressure on the journals, and the last gives insurance against shake of the engine, as a whole, on its foundations. These dynamic actions and adjustments have been the subject of many and extended investigations, both mathematical and experimental, and the result has been admirable success in the improvement of the standard engine of the time in this respect, and beautifully smooth running, where intelligence and experience have conspired in design and construction. It is proposed to consider the economics of such an engine, assuming it to represent the best contemporary practice in these respects, and to be ready for operation under at least ordinarily favorable conditions. The exact expenditure of heat, steam and fuel under specified representative conditions of this case, including steam-pressure, back-pressure, ratio of expansion, and boiler-efficiencies, can be computed for the thermo-dynamic, ideal case; and, knowing the magnitude and conditions of physical operation of the engine, friction included, its wastes of energy, whether thermal or dynamic, can be very closely obtained by computation, and these wastes being added to the total thermo-dynamic expenditure, the gross outlay of energy becomes known and the economical problem can be solved. The following is an illustration of these facts, as determined for an "automatic" simple condensing engine, rated at ten to fifteen horse-power; having a cylinder six inches in diameter and eight inches stroke of piston, its speed 280 revolutions a minute, and the machine proportioned for a steam-pressure of 100 pounds, though strong enough to be driven, if necessary, with a much higher, perhaps, with little risk, at fifty per cent. higher pressure. Compression is complete and leakage insensible.

It is proposed to compute the demand for heat and steam for the purposes of designer and purchaser, on the assumption of the data given below, the conditions as to waste being substantially those illustrated in the Sandy Hook experiments of 1884. Pressures are taken from seventy-five to 155 pounds per square inch above the atmosphere; ratios of expansion from 1.6 to 16, and the engine as speeded at 280. External wastes of heat are assumed to average 0.5 b. t. u. per square foot of external surface and per degree range of temperature from atmospheric—here taken as 100 degrees Fahrenheit. Internal wastes are taken as aggregating, as a fraction of the total steam supplied,

$$w—a/d.\sqrt{r}\,n$$

where the coefficient $a=4$ in the case assumed to be fairly represented of that here considered; d is the diameter of cylinder in inches, r the ratio of expansion, and n the number of revolutions per *second*. This simple expression will probably answer present purposes, in the absence of a more exact and better established one. Friction wastes are taken as found for short cut-offs, efficiency of the engine as a machine being assumed at 0.85. Better work than this can be and should be done. J is taken as 778. The following are the assumed data:

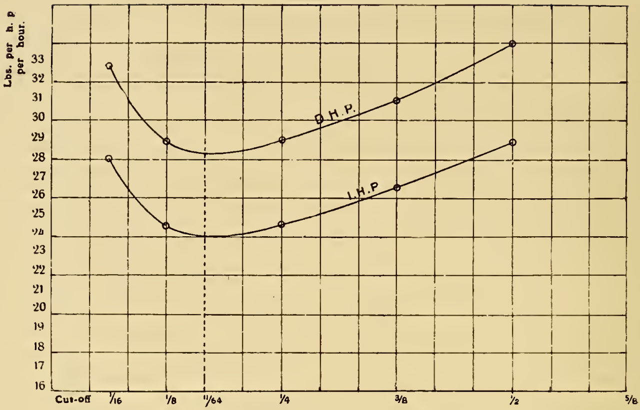


FIG. 3.—ECONOMY AT 115 LBS. PRESSURE.

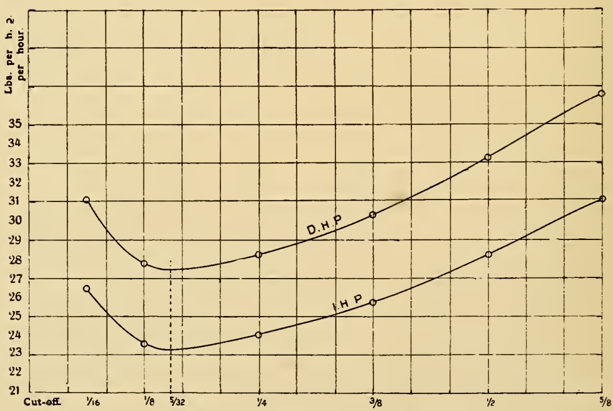


FIG. 4.—ECONOMY AT 135 LBS. PRESSURE.

DATA.

$p_1=75$	95	115	135	155
$p_3=5$	5	5	5	5
$r=1.6$	2	4	8	16
$\frac{1}{r}=\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$

Pressures are here measured from absolute zero.

The work per cubic foot of steam is here computed by the familiar expressions of Rankine :

$$U D_1 = J D_1 \left[T_1 - T_2 \left(I - \log_e \frac{T_1}{T} \right) \right] - \frac{T_1 - T_2}{T_1} l_1 - r\,(p_2 - p_3)$$

and

$$p_2 = U D_1 / r.^*$$

The results of these computations, as made and checked by Messrs. C. B. Auel, A. R. Henry and F. P. Ide, following the methods prescribed by the writer, are presented in the accompanying table.

An examination of the figures here collected will show in a most interesting manner the gradual variation of steam consumption with change of expansion at each pressure and a comparison of the figure for the several pressures will illustrate the interesting modifications of result due to variations of expansion with pressures, and the differences in the location of the best points of cut-off for these pressures. These instructive comparisons are best made by the construction of curves, of which the co-ordinates are, for each pressure, weights of steam demanded per horse-power and per hour at stated ratios of expansion. Such curves have been drawn by the computors for the present case, and are illustrated in the accompanying plates. It is seen that at the lowest pressure, 75 pounds, maximum economy of steam and fuel is attained at a cut-off very near 7-32, or a ratio of expansion of about 4.5, when the dynamo-metric power is taken, or at about a cut-off of 0.2 and $r=5$, on the basis of indicated power. These figures become about 3.16 and 5 at 95 pounds, 11-64 and 6 at 115, 5-32 and 6.4 at 135, and 9-64 and 7 when the pressure becomes 155 absolute, or 140 pounds by gauge.

This gradual shifting of the ratio of expansion giving highest economy of fuel and of steam is better illustrated in the last set of curves in which two exhibit the variation of this point of cut-off with varying pressures, while the other pair show the progressive gain in economy of fuel and of steam in a similar manner ; the numerical values of the former quantities increasing and the latter decreasing with rising steam-pressure. The weight of steam consumed is not far, at best, from

$$w = 250 / \sqrt{p}$$

pounds of steam per hour per indicated horse-power, when working under best conditions, and the best ratio of expansion, on the same basis, is about

$$r = 0.5\sqrt{p}$$

The conditions here assumed may be taken as fairly representative of good practice with such an engine. Where leakage occurs, or when compression is incomplete and the clearances thus become sources of additional wastes, these figures may be much exceeded. Experiments with an engine of such dimensions and proportions as are here assumed, as made under the eye of the writer, have given internal wastes through these faults of construction and of operation, amounting to three times that here found, and bring the expenditures of steam and fuel up to much higher figures. Those here obtained, however, correspond with working conditions, which can probably always, with care, be obtained in the actual case, and may serve as a guide in the designing or selection of such engines for use. Larger engines will be less subject to such wastes, and the margin between the ideal case and the actual may be thus reduced approximately in proportion to increasing size of engine. The economically desirable ratio of expansion and point of cut-off, however, is always somewhat less than that found to give lowest expenditure of steam and fuel, since every item of cost in the construction of the engine

* Rankine's Prime Movers ; Thurston's Manual, p. 398.

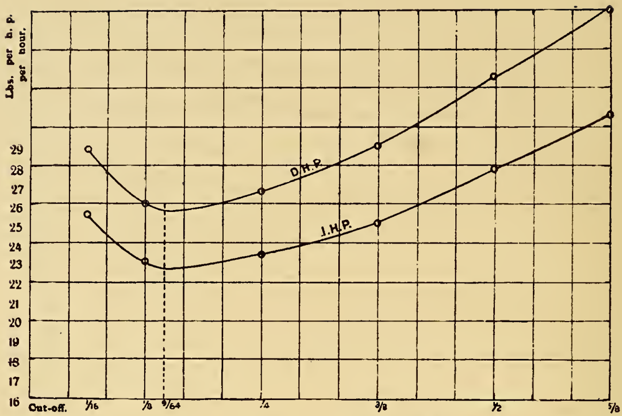


FIG. 5.—ECONOMY AT 155 LBS. PRESSURE.

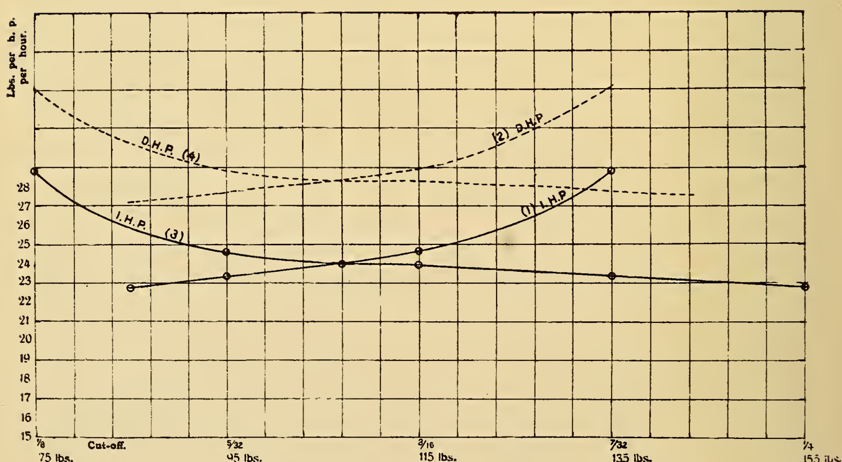


FIG. 6.—ECONOMIES WITH VARYING PRESSURES.

involves a corresponding annual charge thereafter, and a compromise between increasing annual expense on this count, and decreasing cost of fuel must be made to secure the best results.

The commercially desirable ratio of expansion is always less than that giving maximum duty ; but the margin between the two depends greatly upon the relative costs of construction and of operation of engine and boiler and cost of fuel. Methods of exact computation are becoming developed and approximate methods are well known.* In general, at the commercial centres, the ratio to be adopted in designing will not be far from two-thirds that here found to give best effect for the ideal case, twenty per cent. lower than is shown on the diagrams for the actual case, and still lower where it is sought to make the most out of an engine already set and in operation.

The mean effective pressure here found is seen to be not far from

$$p_2 = 6 \sqrt{p_1}$$

and the pressure to be adopted by the designer for such cases will be greater, perhaps not far from

$$p_1 \quad 5 \sqrt{p_1} -$$

gauge pressures being here taken while the power of the engine is seen to be approximately

$$I.\ H.\ P. = 0.03\, d^2 \sqrt{p_1}$$

nearly and slowly rising with increasing pressure. Had the wastes of the engine been larger, which is oftener the case than the opposite, the cut-off would be deferred, the ratio of expansion lessened, the mean effective pressure increased and the relative power for a given size of engine increased, since in such cases the gain by reduction of wastes more than offsets the thermodynamic gain by the reverse process of increasing the ratio of expansion. The figures here obtained may be taken as representing the limit of expansion in the case of the best makes of automatic engine, under best conditions of operation. In the usual case, a lower ratio of expansion and larger mean pressure will be desirable.

* Manual of Steam Engines, Vol. I., Chapter VII.

THE MECHANICS OF DENTISTRY.

By Prof. John E. Sweet.

PEOPLE advanced in life, as they shudder over the remembrance of their childhood tooth ache, may be partially relieved as they think of what appears to them the modern discoveries of chloroform, ether, laughing gas, etc., and again shudder as they learn of or experience the torture which some of us have endured in profiting by the recent achievements in dentistry. As this is simply to be a record of personal experience the personal pronoun is unavoidable and no attempt will be made to disguise it.

Having one's childteeth pulled by a string made of twisted black thread in its mother's hand, is to dentistry as the boy's wind mill on the barn, or water wheel in the brook, is to the mechanics of life. The terrors of the turnkey, an ancient instrument of torture, had in the writer's boyhood days begun to give way to the forceps at the time of his first experience. Having been told as usual that the forceps "didn't hurt anything like as bad as the turnkey," and with a tooth thoroughly well hollowed out by decay, a week's misery with the tooth ache, a doctor sent for at the village two or three miles away to do the work, and with courage entirely evaporated, I was set down like an exclamation point by the vigorous hand of a stern parent to be operated upon. Of course, the tooth at once having stopped aching, as teeth always do, it was properly cut around and I was sure that if they would leave it alone it would never ache again, but they thought differently. So the doctor put on his (till then well concealed) forceps, and in getting a good firm hold crushed the shell and broke it off level with the jaw bone. It is probable that my first experience equaled any subsequent one, and as punishment to a sick tooth hurts worse than a well one, it can easily be imagined that a dancing, howling jack was conspicuous for some hours after. Without remembering particularly what followed, it is likely the root died, as it turned over on its side, I remember, some years later, and was removed by a more skillful operator. In fact, by the very dentist who first used weldable gold in fillings. I forgot all the particulars of this weldable gold discovery, though told some years later. Dr. Westcott's first idea was, on receiving the leaf (which when two pieces came in contact so adhered that it was difficult to separate them), to return the book to the makers, but upon further experiment he discovered that he could pack a number of leaves together, roll them into a roll and draw them out like a bar of lead or iron. From this he concluded it was exactly the right thing and ordered the same sort ever after. One or two other tests of early day experience will aid in giving knowledge of the practice of the time. Like the supplanting of all established devices by more modern ones the turnkey died hard. Among my many other early experiences, after suffering to the limit of endurance with a molar and courage up to the sticking point for pulling, the village dentist argued in this wise: That the turnkey was the best thing to start a tooth with, but that it twisted it over, and that if he started it with the turnkey first and then took the forceps that it would be much easier. As I remember it there were two big hurts instead of one.

Later another doctor had a better plan. He used the turnkey, but instead of twisting the tooth out he lifted it out with his thumb, using the turnkey to get the grip.

About the time chloroform began to be experimented with, and some bad effects were produced or fatal results

occurred from its improper use, people hesitated and the use of electricity was tried with partial success, either in fact or in a way to allay the fears of the patient. The wire from one pole of a battery was attached to an instrument and the end of the other wire to a handle the patient held in his hand. As the instrument came in contact with the tooth, the circuit was completed so the sensation of a shock from a battery was substituted for the pain of extraction. I cannot testify as to its supreme efficiency, as in my own case the tooth was broken by the first attempt and the job finished without the shock. Of course the final operation was like pulling teeth. The electricity dodge did not long survive.

Later I had a plan of my own (one's own plans are generally better). This time there were two advantages, first, it was my own plan, and second it was abroad, and the operator was an American. The secret of the plan was to go slow and just wiggle the thing out as you would a nail with a pair of pincers. It was an improvement ; still I realized that there was a man at each end of the instrument, at least at my end.

A front tooth broken off about half way down, died from the effect, and a false tooth substituted by filing down to the gum, fitting in the new tooth and drilling down into the root and doweling in the new tooth by a maple dowel. This was a common practice and a success for years. A new maple peg was required occasionally.

Cavities for filling were cleaned out and the anchor holes all cut by the delicate steel tools of which very little in the shape of steel tools has ever been done of a superior quality. Rotary mills with the grist mill motion have superseded the hand tools to a large extent, to the advantage of the dentist, but not to the comfort of the patient, unless it be that it shortens the time, and as if the punishment incident to pressure of a hand tool used in forcing in gold filling was not sufficient, the use of a mallet and punch is brought into play.

False teeth preceded by the extraction of one's natural possessions, good, bad and indifferent, and supplanted by artificial ivories attached to a gold or rubber plate, joint partners with the forceps and filling, is one of the horrors I escaped, to profit by the greater horror. Crowning and bridge work ; as the latter includes the former the experience in that will crown the subject.

First, after filling one's gullet with the product of the laundry his mouth is filled with a bowl of mortar made of plaster of paris well troweled in and allowed to set. This is broken out in as large pieces as can be got to hang together and the pieces assembled making a mold ot one's mouth. While you are home thinking about it a cast is made in the mold and you are shown a copy of a worse piece of dilapidated jaw than you ever supposed you were the owner of. It is pointed out that after curing the diseased teeth, by extracting this fang, straightening up this tooth, cutting off and capping four on the lower set, carrying out a saddle here, cutting off and capping two on the upper, putting a half cup on those three and bridging there that you can have a good serviceable set of teeth. Questioning if some of the operations were not approaching murder, received the assurance that no one had died through the operation as yet. Punishment, misery and torture cannot be avoided or much modified in any ot the dental operations except in extracting, and where negligence has led to the necessity for that the one that does not profit by the use of antiseptics (provided there is no heart trouble to prevent) suffer the misery for their folly. But if the torture cannot be avoided it can be immensely increased by permitting the dentist to proceed with the mechanical work upon diseased teeth. In the writer's case the treatment of the diseased teeth was carried on at the bottom end of four or five while the top was being dressed into shape.

The principle upon which the bridge work is founded is to use such of the good teeth as remain sound for piers and abutments, and bridge across from one to the other with a bridge of gold

which carry a series of enamel facings representing teeth to give a natural appearance, the gold bridge serving the real purpose for mastication. Each case of course becoming a seperate study, which gives scope for good judgment and often genius. In some cases bands surround the teeth which only have to be ground into proper shape to receive them, and in other cases the teeth are cut off half or two-thirds down and the stump capped and the gold bridge attached to this cap. The method of cutting off is to saw into the tooth a short distance outside and in and then with a pair of stout cut nippers cut the piece off as one would a piece of wire. This exposes the pith or nerve of the tooth, to remove which a pointed pegwood stick is driven in forcing the live pulp out. The hole or cavity is then drilled out to make it parallel to and as near the bottom of the root as is safe. What remains of the tooth above the gum is ground approximately round, intentionally slightly tapering and around it is formed a tightly fitting tube of gold plate with its lower end cut and sharpened so as to fit down tight to, or drive in between the gum and the root of the tooth. These tubes are cut off slightly above the tooth and a gold plate cap fitted and soldered in, or what is in fact a cap to a pile, as the civil engineer would term it, and is the abutment for the bridge. If there should be two or more vacant spaces in the jaw and two or more teeth between, all the intervening teeth may be cut off and capped this way.

Besides these caps and the bands before mentioned other attachments, such as circumstances in the case may dictate, as studs or saddles, are resorted to.

The fit of the tubes on the teeth are made so tight that the dentist's mallet is used to drive them on and the punishment when the tooth is sick is only less than the treatment of the sick tooth itself, because the time is shorter. Scraping the root of a diseased tooth down to near its very end and treating it to a dose of sulphuric acid, is a little trying, and driving a tube on with a mallet the same day is repeating the dose too frequently.

When all the teeth, of one jaw at least, are dressed into shape and capped, another plaster mold is taken from the mouth with the caps on. When this is removed and reassembled, the caps are removed and set in place in the mold, a new cast is made either of plaster or fusible metal, and with the caps placed upon this cast, the dentist has a model jaw, with a clear chance to construct the bridge soldering it to the caps, and removing the skeleton it is ready to try on. In the writer's experience this was the most trying job of all. Being put under the influence of ether it was sprung on and driven into place. The operation so displaced every original root that I was forced to cry out for relief. The bridge was pulled off and out came with it three of the sick teeth that had caused such a world of misery in the treating and hammering operations. After some weeks of despair I was induced to submit to further operations, and going over the same performance with new molds and the cutting off of another tooth or two, a new plan was adopted with more satisfactory results.

When after a half dozen trials the thing is brought into shape according to the dentist, but feels in your mouth like a piece of cobble stone pavement, it is cemented in, that is, the caps or tubes which fit over the teeth are filled with a quick setting mortar which the dentist gives the more elegant name of cement, and the teeth plastered over with the same material, the artificial work is placed on the natural and either driven down with a mallet or you are invited to bite down on it as hard as you can. By the combined efforts the bridge is lowered and the mortar allowed to set. This is a chemical operation and to many the worst feature of it all, but in the writer's case happiness compared to the punishment of capping the diseased teeth.

Next comes the dressing up or articulation, that is making the teeth on one jaw strike in even with the other, roughing the meeting surfaces so as to give them the masticating qualities, and then

weeks of annoyonce trying to become accustomed to the horns and projections in one's mouth. This in my own case went beyond endurance and I had several of the worst places ground away. Later, ulceration set in and I had two or three of the overhanging teeth and a saddle sawn off. In the mean time two or three of the porcelain facings peeled off and in replacing these some good dodges were resorted to. One plan for restoring these facings, which are made with two projecting platinum rivets, is to cut off the old rivets, drill holes through the gold, crowd the facing into place and rivet the rivets on the inside. This has not proven a success, because platinum is not a good thing to rivet and because very few know how to head a rivet any way.

Were the rivets of gold and the holes properly countersunk on the inside, that is with a tool as slim as sixty degrees, the rivet could be headed in the following manner and be as rigid as the metal itself.

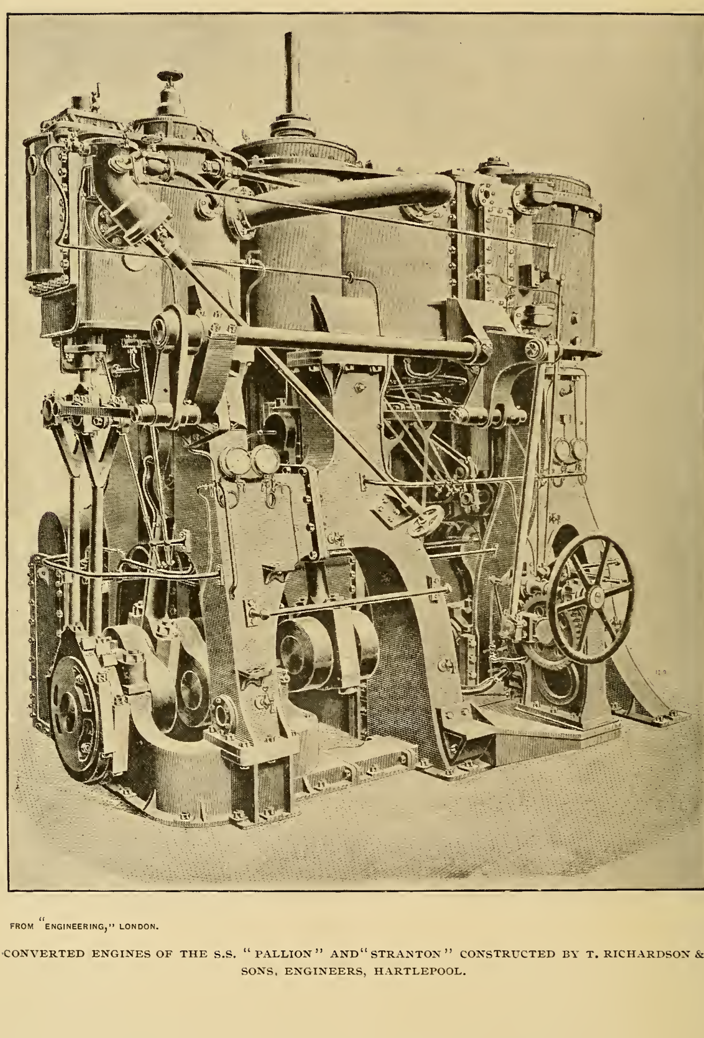
Assume that it required ⅛ inch to form a head. Use a pair of bent plyers with one horn covered with a vulcanized rubber pad to press on the facing and two holes of the size of the rivet drilled in the other horn. One hole one-twelfth of an inch deep and the other one twenty-fourth inch deep. With the deep hole first forced on the rivet it will be upset to the extent of one twenty-fourth between the plyers and its connection to the facing filling the hole in the bridge, next force it down with the shallow hole and lastly with the flat surface and a head will be formed that nothing can work loose.

Another method is to drill out the old rivets and slot out the metal between, making a horizontal mortise with the ends widest inside. The new facing being put in and the two pins bent apart forms a dovetail, so that when the space is filled, which is done with amalgam, a fairly strong connection is made, but one that is difficult to hold absolutely tight for the reason that it is hard to force out the pins securely to the ends of the mortise. A gold key driven in, in place of the amalgam, would be better.

The last plan tried upon my golden crowns is as follows: First, the pins were drilled out and the space cut into a mortise as in the other case. The ends of the two pins in the facing bent together and soldered, forming a staple or loop, which was passed through the mortise and a gold key driven through the loop after a proper groove had been ground into the gold bridge to receive it. This is an absolutely secure way and perfectly free from any disagreeable projections on the inside.

It would not be fair to the profession, not to say that all the work during the later years' experience has been done by men of the highest standing and the bridge work under the direction of a popular non-resident professor of one of the most prominent dental colleges, and too, it would not be fair not to say, that the consolation has probably balanced the misery.

Should any young people read this some good will have been done if they take warning and have their teeth attended to when they first need it.



FROM "ENGINEERING," LONDON.

CONVERTED ENGINES OF THE S.S. "PALLION" AND "STRANTON" CONSTRUCTED BY T. RICHARDSON & SONS, ENGINEERS, HARTLEPOOL.

ECONOMY OF TRIPLE EXPANSION ENGINES.

THE great economy of the triple expansion engine is well illustrated by a test of compound engines which were converted to triple expansion engines.

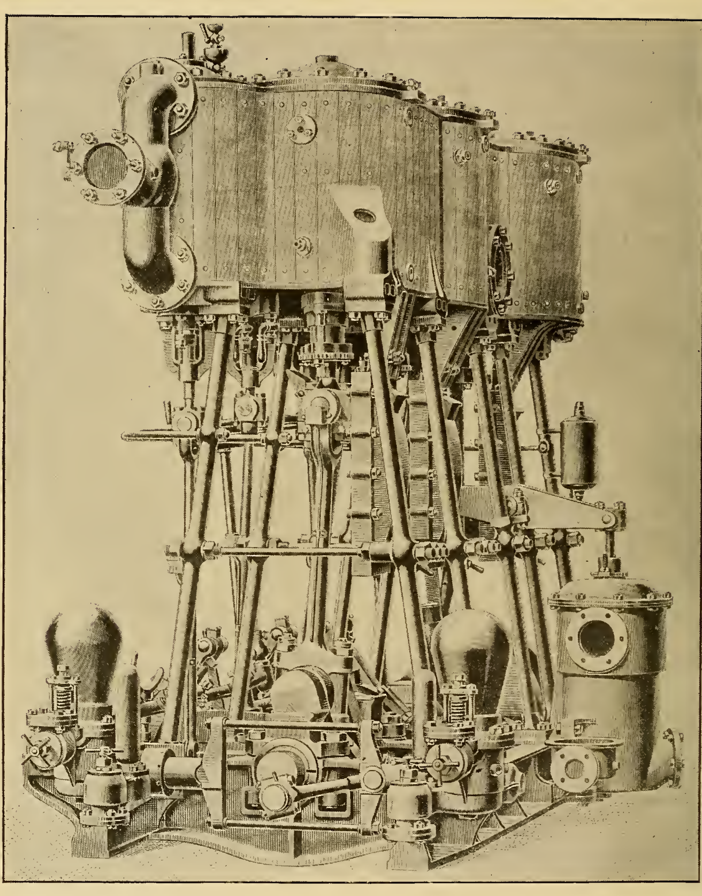
The illustration on page 64 represents sets of marine engines on the steamships "Pallion" and "Stranton." These vessels were built in 1879 and 1880 for the West Hartlepool Steam Navigation Company, and were fitted with engines by Messrs. T. Richardson & Sons of Hartlepool, the sizes of the cylinders being thirty-three inches and sixty-one inches, with a stroke of two feet nine inches; the working pressure was seventy-five pounds. They have recently been converted to triple expansion by the same firm, the method of alteration being as follows :

The original boilers were removed and replaced by two of the single-ended type, twelve feet nine inches in diameter and nine feet nine inches long, the working pressure being 170 pounds. Each boiler was fitted with two of Morison's suspension furnaces of three feet nine inches in external diameter, and there is no doubt that the high evaporative efficiency obtained from the boilers is due to the furnaces being of large diameter and of minimum thickness, with a comparatively short grate bar. This arrangement allows of more perfect combustion than is possible in a small furnace, and at the same time it offers a length of fire which is easily worked by an average fireman.

The old engines were utilized as far as possible, the original cylinders being retained and used as the intermediate and low-pressure cylinders, the latter being reduced in diameter to fifty-six inches by means of an independent liner. The condenser, soleplate and pumps were also retained, with the exception of the feed pumps, which were replaced by others suitable for the increased pressure.

A new horse-power engine complete was fitted to the forward end of the crankshaft, which was altered and provided with an additional crank, the three cranks being set at angles of 120 degrees. The original high-pressure column was removed and replaced by one binding the new high-pressure cylinder to the intermediate, as shown on the engraving, and a casting was bolted to the condenser at the back of the engines and forms the back support of the high-pressure cylinder. The reversing shaft was lengthened to operate the high-pressure valve gear, and a new reversing engine of the all-round type was provided.

The chief feature of the engine, however, is the novel arrangement of the high-pressure cylinder, the improvement being based upon the fact that the greater the circulation over a heat-giving surface the greater is the amount of heat transmitted. The cylinder is jacketed with steam at boiler pressure, and the outside of the jacket is surrounded by the first receiver, the design in this respect being similar to the practice in the early days of compound engines, in which the exhaust steam from the one cylinder flowed directly to the steam inlet of the next. The defect in this arrangement was that only a small portion of the steam came into actual contact with the jacket, as the circulation was practically confined to the steam in the direct line of passage from the exhaust port of the high pressure to the steam port of the low-pressure cylinder. In this engine, however, the receiver is provided with a number of circulating channels which cause the steam to flow uniformly over the whole heat-giving surface of the jacket on its passage to the intermediate pressure engine. The channels are formed by ver-

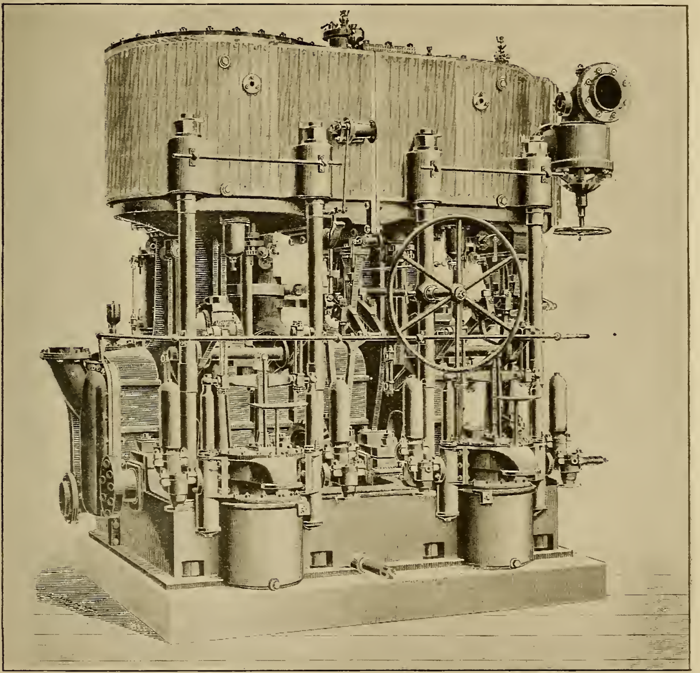


FROM "ENGINEERING," LONDON.

ENGINES OF THE ROUMANIAN FIRST-CLASS TORPEDO BOAT "NULUCA," CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERANEE, HAVRE.

tical partitions, and the direction of flow being consequently of a zig-zag nature, the steam is continually mixed up, and not only does it abstract a large amount of heat by means of its rapid flow, but the whole body of steam being continually intermingled, it is thoroughly dried before entering the intermediate-pressure cylinder.

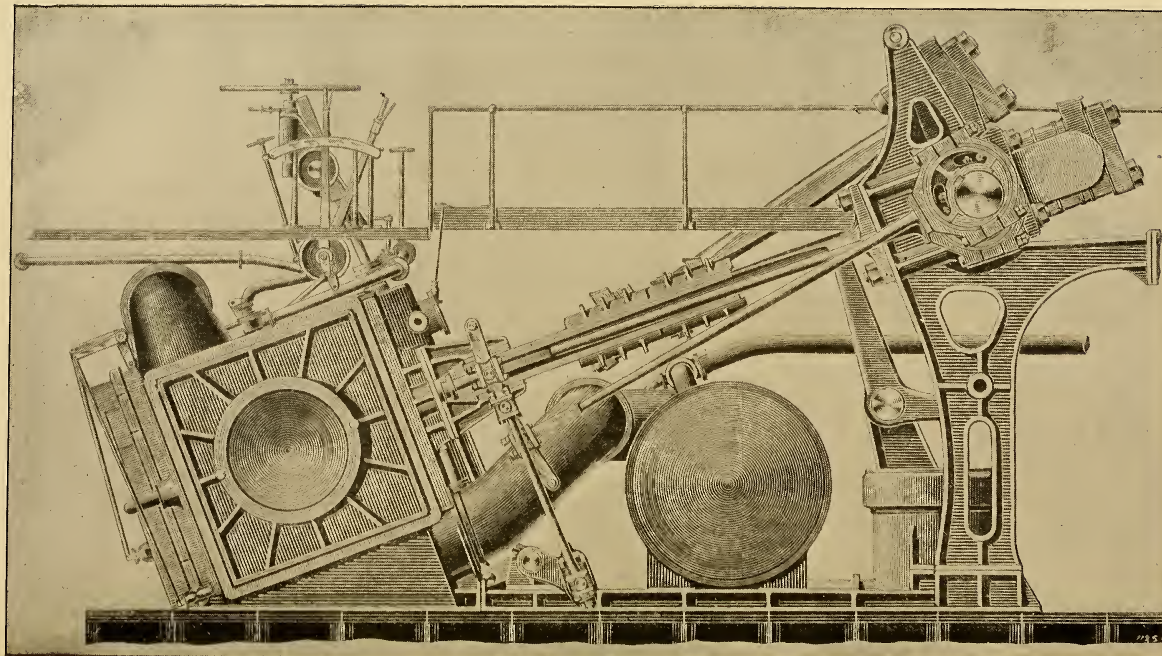
spindle glands, and by the rapid destruction of fibrous packing. With the circulating receiver, however, the steam is so thoroughly dried before entering the intermediate pressure engine that there is no water carried into that cylinder. In the case of these vessels registering drain traps were fitted, but practically no water was drained off.



COMPOUND ENGINES OF THE HAYTIAN DESPATCH-BOAT "TOUSSAINT-LOUVERTURE," CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERANÉE, HAVRE.

It is well known that in the ordinary design of triple-expansion engines a large amount of condensation takes place in the high-pressure cylinder, and that a great deal of water enters the intermediate pressure cylinder. This is evidenced by the amount of leakage past the piston-rod and valve

Another feature in the arrangement is the combination of an evaporator for producing fresh auxiliary feed water with a steam jacket. In this case a Morrison's evaporator is connected to the high-pressure jacket at its lowest part, thus making the jacket drain directly into the heating coils of the

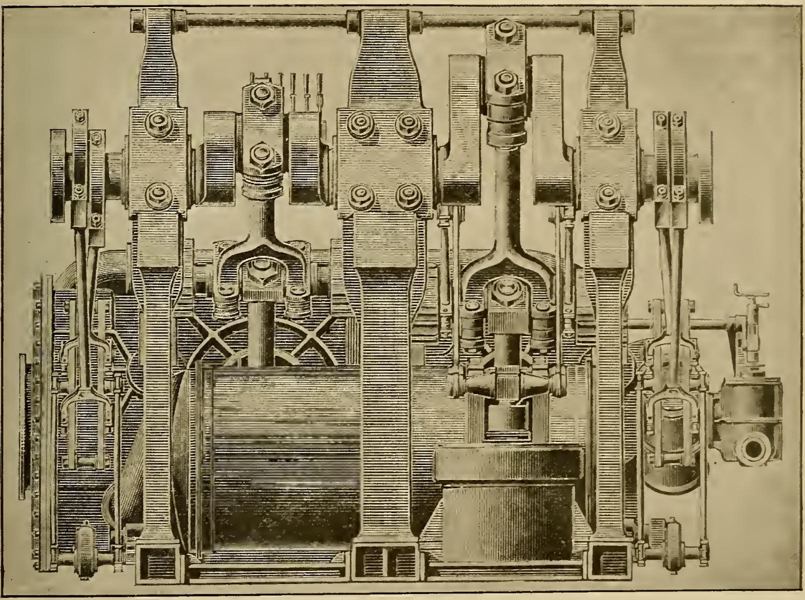


COMPOUND PADDLE ENGINES OF THE 'GLEN SANNOX.' CONSTRUCTED BY JAMES & GEORGE THOMPSON, LIMITED, ENGINEERS, CLYDEBANK.

evaporator, and in addition to automatically draining the jacket, increasing the circulation of steam therein by the amount used by the evaporator, which steam is still further utilized to heat the feed water on its passage from the hotwell to the feed pumps.

The value of these arrangements, which have been designed by Mr. D. B. Morrison, the manager of Messrs. T. Richardson & Sons, is shown by the consumption of coal was 12½ to 13 tons per day, with a speed of 8½ knots.

The reduction in the coal consumption was, therefore, 4½ tons per day, or in other words for the same speed, the coal consumption with compound engines was fully 50 per cent. in excess of the present consumption with the tripled engines. In dull times such as these, the fact that such results can be obtained by tripling the machinery of



DETAIL OF COMPOUND PADDLE ENGINES OF THE "GLEN SANNOX."

the results obtained. In order to obtain reliable data from ordinary working at sea, 140 tons of average coal was put into one of the bunkers at Blyth. All the coal used on the voyage to Port Said was taken from this Bunker, and on arrival it was found that the average consumption per day had been 8½ tons with an average speed of 8.6 knots. Formerly many of the older ships should cause shipowners to give the matter their careful consideration. There seems no doubt that many ships now working at a great disadvantage with compound engines might be made to show a satisfactory dividend if the machinery was converted as successfully as in the cases we have related.

The great progress in the designs and

construction of marine engines is being exemplified constantly in naval as well as passenger and freight vessels.

It seems but a short time since the compound engine began to revolutionize the shipbuilding interests, but the past few years have been fertile with demands for higher speed and larger powers, which have been met by the construction of triple expansion engines.

On pages 66 and 67 are illustrated two types of marine engines constructed by the Forges et Chantiers de la Mediteranée of Havre. The former engines were built for the Haytian despatch boat "Toussaint Louverture," which was launched in 1886 from the plans of M. Marmiesse, engineer of the works.

The engines were constructed from the plans and under the superintendence of Mons. Landeau. They are of the compound inverted type of the following dimensions :

High-pressure cylinder	26 in.
Low " "	45 in.
Stroke	23.6 in.

There are two boilers, having 84 square feet of grate surface, 2176 square feet of heating surface, and working at a pressure of 78 pounds.

The engines on page 66 are of the type fitted to three torpedo boats named "Naluca," "Smeul" and "Sborul," built for the Roumanian Government. They are of the triple compound type, as follows :

High-pressure cylinder	12.2 in.
Intermediate-pressure cylinder	17.7 "
Low-pressure cylinder	26.7 "
Stroke	14.9 "

The locomotive boilers have :

Grate surface	20.4 sq. ft.
Heating surface	1072 "
Pressure	156 lbs.
Horse-power	540

The speed stipulated for was 20 knots under the conditions of trial observed in the French navy. The results obtained were:

"Maluca"	20.325 knots
"Smeul"	20.681 "
"Sborul"	21.007 "

The consumption of fuel was 1.34 pounds per horse-power per hour at 11 knots, and 1.56 pounds at 15 knots. At 20 knots it was below 1.87 pounds.

For the description of these engines and the illustrations we are indebted to *Engineering*, of London.

After a recent test of the air brakes of the New York Air Brake Company, the vice-president of the New York Central and Hudson River Railroad wrote to Royal C. Vilas, president of the New York Air Brake Company, as follows :

Dear Sir—Replying to your letter of last week, I would state that a full and detailed report from Mr. Dudley on the tests recently made by us of your automatic quick acting brakes, will not be ready until some time in October.

I have, however, a preliminary report from Mr. Dudley, and also reports from Voorhees, general superintendent, and Mr. Buchanan, our superintendent of motive power and rolling stock, both of whom were present at the tests.

The gist of these reports is that, from a practical operating standpoint, there is no difference between the operation of the Westinghouse air brakes and the air brakes of the New York Air Brake Company ; and the tests where the cars in the train were mixed, a portion being equipped with the brakes of one company, and a portion with the other, showed as good results as when either brake was used separately.

We are satisfied that there are no practical objections to allowing the cars equipped with the New York brake to be used in conjunction with those equipped with the Westinghouse brake.

I have, therefore, issued orders removing all restrictions as to the use of cars equipped with your brakes ; and, hereafter, cars so equipped will be received and operated by this company and treated precisely the same as the cars equipped with the Westinghouse brake. Yours very truly,

H. Walter Webb,
Third Vice-president.

NINE HUNDRED AND FIFTY MILES BY TELEPHONE.

By Miss A. Dickson.

TELEPHONY, or the propulsion of sound to a distance, is one of the many branches of science which owes its sudden maturity to the latter half of this prolific century. Traces of the art may be dimly discerned through the past centuries, but experimental knowledge was at too immature a stage to admit of the full development of the idea. Robert Hooke, in 1667, thus describes his success in projecting sound over a tightly drawn wire :

"'Tis not impossible to hear a whisper at a furlong's distance, *it having been already done ;* and perhaps the nature of the thing would not make it more impossible, though that furlong should be ten times multiplied. And though some famous authors have affirm'd it impossible to hear through the thinnest plate of muscovy glass, yet I know a way by which 'tis easie enough to hear one speak through a wall a yard thick. It has not yet been thoroughly examin'd how far otacousticons may be improved, nor what other wayes there may be of quick'ning our hearing, or conveying sound through other bodies than the air, for that is not the only medium. I can assure the reader that I have, by the help of a distended wire, propagated the sound to a very considerable distance in an instant, or with as seemingly as quick a motion as that of light, at least incomparably quicker than that which at the same time was propagated through the air, and this not only in a straight line, or direct, but in one bended in many angles."

Canon Gottoin de Coma, a contemporary of Volta, in the year 1785, dwells at length on the sounds emitted by an iron wire affected by a discontinuous electric current. Again, in the Repository of Arts, September 1st, 1821, the writer describes a new wonder, yclept the telephone, the work of one Wheatstone, and indulges in many glowing prognostications as to the resources of the new invention, advancing the startling claim that the music of an opera, performed at the King's Theatre, London, may ere long be heard simultaneously in various remote portions of the great city. He concludes with the pregnant prophecy, "and if music be capable of being thus conducted, perhaps words of speech may be susceptible of the same means of propagation."

The first crude application of electricity to the transmission of sounds was supplied by an American named Page, in 1837, and was based upon the discovery that an iron jar, alternately magnetized and demagnetized, gives forth distinct notes. Upon these slender grounds Philip Reis of Friedrichsdorf, Germany, constructed his first rude telephone, substituting an iron wire for Page's jar, and this was exhibited before the Physical Society of Frankfort in 1861. A host of competitors, great and small, appeared in the train of these successful pioneers, but the full fruition of the idea was reserved for the ripened intellects of Graham Bell, Elisha Gray, Hughes and T. A. Edison. In 1873 the latter commenced a series of experiments, crown-

ed by the present telephone in all its numerous developments. In 1874 Elisha Gray of Boston produced a method of electrical transmission, by which speech could be propelled to considerable distances in much of its original purity and strength. Simultaneously appeared Alexander Graham Bell's patented and improved methods of transmitting speech with all its varieties of tone-color and rhythm, all of which will be seen to have marked a distinct era in this science, which, prior to Reiss' first crude experiments, had been limited to the propagation of musical notes, and had not yet arisen to the dignity of articulate speech. Immediately upon this (1877) followed Edison's carbonic transmitter, based, according to the inventor, upon the principle of the variable resistance of carbon under pressure. This transmitter, which has now passed into universal use, and which has been of the most incalculable service in securing satisfactory acoustic results, was the offspring of a seemingly accidental discovery. The inventor's attention had been drawn to the dense blackness of some soot, the product of a smoking petroleum lamp, and detaching a portion he molded it into the shape of a carbon button, in connection with the telephone then in process of completion. The results were so marvelous that Edison pursued his investigations night and day, regardless of the claims of hygiene, and never desisted until his labors culminated in the perfected transmitter and other scientific appliances.

Professor Hughes, in 1878, threw much valuable light on the workings of the telephone, and materially assisted in the solution of problems which had baffled the ingenuity of leading scientists. He disputed the statement advanced by Edison in regard to the carbon transmitter, and ascribed its action to the principle of loose contact.

The field of telephony was now ably and hotly contested, but Edison and Bell outstripped all competitors, and their methods met with impartial endorsation at the hands of European judges. The English Mechanic of 1880, says: "The instruments chiefly used are the Bell and Edison telephones or a combination of the two." The Birmingham Daily Post (1879), says of the Edison loud-speaking telephone: "Every inflection and intonation of the speaker's voice is instantly reproduced, with such fidelity that the result constitutes a constant miracle. * * * The Edison telephone, the operators being miles away from each other, will faithfully convey a secret, a speech and a song." The Boston Evening News of 1880, remarks: "Ease, rapidity, certainty and privacy are the great advantages of this system."

The conservative instincts of the British lion are such as to deprecate any poaching on his scientific preserves, and the readiness of that formidable animal to endorse the new methods is in itself a strong proof of their intrinsic excellence. From 1879 and 1880 until the present date the European press has been almost unanimous in its praise. It records the facilities attained, dwells admiringly on the perfect manner in which the varied undulations of the human voice are reproduced, and predicts yet greater developments, all of which seem in process of verification. The London Telephonic Exchange is now one of the most indispensable branches of scientific commerce, and although somewhat hampered by the peculiar geographical structure of the huge metropolis, and the unwarrantable restrictions of government, it constitutes one of the bulwarks of civilization, and supplies indisputable evidence of America's prominence in progressive science.

London is also supplied with telephonic service to Paris, a distance of 310 miles; Paris, in its turn, is connected with Marseilles, an extension of 620 miles. Austria is the recent possessor of a line of 314 miles; after which are arranged in comparative importance the Berlin-Breslau line, 219 miles; the Vienna-Brunn-Prague, 219 miles, and the Paris-Brussels, 198.

The culminating point of telephonic achievement, hitherto witnessed by our century, was attained on the afternoon of October 18, 1892, when, together

MR. EGLESTON. PRES. JOHN E. HUDSON. COL. FINLEY ANDERSON
RALPH W. POPE. VICE-PRES EDWIN J. HALL. ASST. GEN. MGR. MEANY.
LOUIS CASSIER. SPECIAL AGENT W. A. HOVEY.
ST. CLAIR M'KELWAY. PROF. ALEXANDER GRAHAM BELL.

with other ardent investigators, the writer attended a public test of the science at the main offices of the Long Distance Division of the American Telephone and Telegraph Company, No. 18 Cortlandt street, New York. The handsome reception room was filled with guests, amongst whom were numbered some of the most distinguished votaries of science. With the presumable intent of blending into one the rival claims of science and establishing a broad basis of mutual harmony, the magic strains of music were brought into requisition. Over the thousand miles of space intervening between New York and Chicago floated the silver measures of a cornet, clear-cut and distinct, but softened, sweetened and spiritualized by that distance which "lends enchantment." Next followed an interchange of courtesies between two civic dignitaries, Mayor Grant of New York and Mayor Washburne of Chicago, during which many flowers of speech were scattered and the cities congratulated on their improved facilities. Prof. Alex. Graham Bell then stepped forward and took his place at the telephone. The grand leonine head of the inventor, his superb physical development, the quiet strength of his manner, and the play of intellect which spoke in the deep eyes, and animated the mobile curves of the face, these riveted the gaze of the assembled guests and held their attention inflexibly until the close of the conference. Prof. Bell's interlocutor was Mr. Wm. G. Hubbard of Chicago, a life-long friend and scientific associate of the inventor, and the introduction of this gentleman won a special significance from the fact that on the occasion of the Philadelphia Centennial in 1876, in presence of the Emperor of Brazil and the famous scientist, Sir Wm. Thompson, Mr. Hubbard officiated as the inventor's assistant, and was the first person to catch the vibrations of the new instrument. An interesting circumstance in connection with the present test was the fact that whilst Prof. Bell's tones, at one time, were totally lost to the writer, stationed scarcely five feet from the telephone, they were distinctly audible at the stupendous distance of 1000 miles by Mr. Hubbard, who repeated them back to Prof. Bell.

The line to Chicago passes by cable under the North river, thence through Newark, N. J.; Easton, Harrisburg, Altoona, Pittsburgh, Pa.; New Castle, O.; South Bend, Ind., to Chicago. Branch lines connect with Cleveland and Toledo in the Eastern States with all the important centres from Portland, Maine; in the East to Buffalo at the North; and to Philadelphia, Baltimore and Washington in the South. Lines are in process of completion from Chicago to Milwaukee, from Toledo to Detroit and to all important points in Ohio, Indiana, Illinois, Michigan and Wisconsin; whilst the communication between Chicago and Boston, a distance of 1200 miles, is already a successful and established fact. A few calculations will give some imperfect idea of the vast aggregate of material employed. Four hundred and thirty-five pounds of copper wire are used to the mile, a total weight of 826,500 pounds, extending over a distance of 950 miles. Two No. 8 drawn copper wires form the circuit, transposed or crossed diagonally without contact, in such a manner as to form what is known as the electrical balance, thus securing a positive immunity from induction. Each mile includes forty-five poles, thirty-five feet in height, made of cedar and chestnut, numbering in all 42,750.

The charge for five minutes' conversation between the cities of Chicago and New York is $9, a moderate sum when the inestimable advantages of instantaneous communication are remembered. It will be seen that the specified time is well calculated to insure celerity, condensation and other attributes indispensable to the satisfactory discharge of mundane duties. It is also calculated to banish those meretricious adornments of speech, classified by Mark Twain as "glittering streaks of profanity." A man may secretly entertain the belief, like the old Scotchwoman, that "sweirin' is an unco gude set-off

to conversation,'' yet he may hesitate to cultivate the art at the rate of $108 an hour. Never has the familiar adage, "Time is money,'' found truer exemplification than in this age of teeming energies, and a system which brings into instantaneous contact the workings of countless minds, is above all praise, and beyond all human compensation.

THE ANALYSIS OF CYLINDER DEPOSITS.*

By Prof. Thos. B. Stillman.

THE deposits in steam cylinders, formed by the decomposition of lubricating oils, may be classified as simple or compound, depending upon whether the deposit is due to the decomposition of the oil alone or if foreign matters, carried over in the steam from the boilers, are also present.

In the former case, carbon, hydrocarbons, oils, and iron oxid are the principal constituents, whereas in the latter oleate of lime, carbonate of lime, and silica are often present in addition to the former.

The following analysis of a sample from a locomotive cylinder would indicate a simple deposit :

Moisture	2.28	per cent.
Oils soluble in ether—animal	10.54	"
Oils soluble in ether—mineral	11.23	"
Hydrocarbons insoluble in ether	47.97	"
Fixed carbon	23.73	"
Iron oxid (FeO)	2.83	"
Undetermined	1.42	"
Total	100.00	

And the one given below, of a deposit from the steam cylinders of a large stationary engine, would show that scale forming material from the boilers had become a component.

Moisture	13.12	per cent.
Oils soluble in ether—animal	8.15	"
Oils soluble in ether—mineral	7.86	"
Soap	2.10	"
Hydrocarbons insoluble in ether	1.67	"
Fixed carbon	2.71	"
Oxids of iron (and aluminum)	6.81	"
Silica	3.65	"
Calcium carbonate	43.22	per cent.
Magnesium carbonate	10.17	"
Undetermined	0.44	"
Total	100.00	

In many samples I have found copper and zinc in the deposits, formed by the corrosive action of the liberated oleic acid from the animal oil upon the brass or composition bearings.

This corrosive action is very marked where a poor quality of lubricating oil, composed of animal or vegetable oil, is used, whereas, a pure neutral mineral oil has no acid action at steam temperature. Oftentimes the statement has been made to me, when the deposit was given for analysis, "All of our lubricating oil is pure mineral oil; we use no other.'' And yet, upon analysis, lard oil would be shown in comparatively large amounts.

This is accounted for from the fact that while the consumer believes he is using pure mineral oil—which was sold to him as such—the manufacturer has introduced from three to thirty per cent. of lard oil.

A large majority of the so-called "pure mineral'' lubricating oils for cylinder use contain at least three per cent. of animal oil; and it is the exception and not the rule to find a "pure mineral'' oil for cylinder lubricating purposes.

An analysis of a deposit from the steam cylinder of a large freight steamer gave as a result :

Moisture	16.16	per cent.
Oils soluble in ether—castor oil	26.19	"
Oils soluble in ether—mineral	32.50	

* From Stevens Institute Indicator.

Fixed carbon	7.92	per cent.
Copper oxid	0.50	"
Iron oxid (FeO)	25.10	"
Undetermined	1.63	"
Total	100.00	

Pure mineral lubricating oil was supposed by the officers of the vessel to be the only lubricant used, and special care had been taken to secure it, but it appears that the engineer added a small amount of castor oil to the mineral oil, as, in his opinion, it made a better lubricant. The decomposition of the castor oil and liberation of the fatty acid was the primary cause of the deposit.

The action of the fatty acids upon the iron and metal bearings results in different products. That is to say, while the copper when present has generally been estimated as copper oxid, the iron may exist only as oxid or as metallic iron, or both.

No doubt the oleic acid acts to form salts of these metals, but it is certain, in many instances, that when formed they are immediately decomposed or partially so, and a resulting mixture formed that is somewhat difficult of analysis.

In the analysis here given it will be noticed that the iron was found both as metal and as oxid.

Moisture	3.77	per cent.
Oils soluble in ether—animal	21.27	"
Oils soluble in ether—mineral	19.60	"
Soap	traces.	
Fixed carbon	10.90	"
Iron oxid	14.01	"
Iron	27.85	"
Lead oxid	0.82	"
Copper oxid	1.07	"
Undetermined	0.71	"
Total	100.00	

THE POWER OF "SCIENCE."*

By F. R. Low, Editor of Power.

An expert sat at his desk one morn,
And his visage was sad and his looks forlorn,
For no client had darkened his office door
In all that week or the week before.

12 O'CLOCK.
"HIS HAND IN HIS POCKET, VAINLY STRAYED FOR THE "WHEREWITHAL" FOR A "LEMONADE."

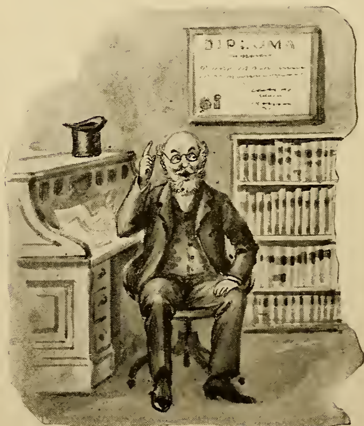
He sat in his chair with a languid lop,
With his feet perched up on his roll-top,
While his hand through his pocket vainly strayed
For the "wherewithal" for a "lemonade."

The ponderous volumes about him showed
That of weighty knowledge he carried a load,
With Mechanics and Statics and deep mathematics
And Thermodynamics he overflowed.

A step is heard on the stair below,
A step that his anxious ear don't know,
With visions of practice his pulses beat
As he puts on his glasses and lowers his feet.

The footsteps ascend. "Quick! a pen and a book
Or something to give a professional look;"
And when his two visitors entered you'd think
No time was allowed him to eat or to drink.

"One moment please, gentlemen, just be at rest
Until I arrange this report of a test."
"There!" Then briskly, "Now gentlemen, what can I do
To render myself of assistance to you?"



12.05 O'CLOCK.
"A STEP IS HEARD ON THE STAIR BELOW."

* Originally printed in Boston Journal of Commerce.

The clients advanced, angry, heated, and red ;
"Here's a tenant of mine, Sir," the elder one said,
"To whom I am furnishing twelve horse or more,
While he isn't willing to pay for but four."

12.06 O'CLOCK.
"THE CLIENTS ADVANCED, ANGRY, HEATED AND RED."

"Oh, you grasping old rascal ! you'll make the man laugh,
When he sees I can't use but three horse and a half ;
My machinery is light, I have little to do,
And most of the time I am using but two."

"Be calm," said the expert, "We'll settle this case,"
With professional dignity stamped on his face,
"With problems like this I have frequently dealt,
Let's see ! to begin with, how wide is your belt ?"

They looked at each other but neither could tell ;
"We never have measured ;" the expert said, "Well,
Is it two, six, or four, can you tell somewhere near ?"
But the clients were struck, they could give no idea.

Then seizing his pencil he laid off a space
Of a width that he judged would apply to the case,
"About this width ?" he asked. With a smile of relief,
They declared it exact, to their honest belief.

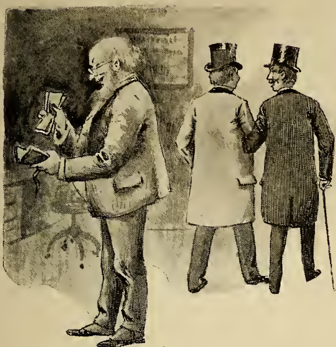
"The diameter, now, of your pulley," he said ;
But neither one seemed to have this in his head,
Until the old expert suggested the size
By holding his hand to be gauged by their eyes.

"The speed of your shaft is the next thing to find ;"
But neither could happen to call this to mind.
"Is it fifty, two hundred, or is it this speed ?"
"There ! there !! that's just it," and this point was agreed.

12.10 O'CLOCK.
"LET'S SEE ! TO BEGIN WITH, HOW WIDE IS YOUR BELT ?"

Then came from his table of logarithmic sines,
The value of a^2, with which he combines
B l, to allow for the belt being tight,
While the clients agree that 'tis wonderful quite.

The expert looked smilingly up from his
task;



12.15 O'CLOCK.
"HIS FEE OF TEN DOLLARS THEY WILLINGLY PAID."

"How much do you make it?" they eagerly
ask;
"Just six and eight hundredths-horse power
exact,
And if figures don't lie there's no doubt of
the fact."

"That's just what I told you," the landlord
exclaimed,
While the tenant averred that is just what he
claimed,
And both of the clients expressed their
delight
At the learning and wisdom that settled
their plight.

His fee of ten dollars they willingly pay,
And in perfect agreement they bid him good
day,
But their steps on the staircase had not
reached the floor,

12.30 O CLOCK.
"THE LEGEND 'RETURN SOON' APPEARED ON THE DOOR."

When the legend "Return Soon" appeared
on the door.

Reflections and Observations.

A FEW years ago Philadelphia and Boston used to be the butt end of all the story-tellers, and even to-day the slowness of the Quaker City and the culture of Boston comes in for a rap now and then.

Chicago, however, having more peculiarities than either of the other cities, seems now to be getting the worst of it. The jokes about the windy city, or as it is often called, the smoky city, were thick enough before it added to its attractions the title, The World's Fair City, and more recently the highwaymen who have been terrorizing the inhabitants of this inland metropolis bring to mind the story I heard many years ago of this wonderful place when the Indians camped around and scalps were hung on bean poles.

A gentleman had promised his little girl that if she would say her prayers regularly every night (a task which he found it difficult to get her to do), he would take her to Chicago the following week.

The little girl, who was only between four and five years of age, promised, and faithfully carried out her part of the agreement.

The night before she was to start on the journey her father said, "Mary, have you said your prayers every night as you promised?"

"Yes, papa," she replied.

"Well, say them now and then go to bed, for I am going to take you to-morrow."

The dear little thing began, and as she got near the end, her father heard her say: "Good-bye, God; good-bye, Jesus; I trust you will save me from all harm. I am going to Chicago in the morning."

++

I WAS one of a party who visited the Watervliet Arsenal not long ago, and like all strangers, we were very much interested in the lathes which were at work boring the immense guns for the government. They were the longest lathes we had ever seen (over 100 feet), being some of the twenty-five manufactured by the Pond Machine Tool Company. One of our party, speaking of them, said they reminded him of the story he heard once of the farmer out in the western part of the State, who lived about ten miles from Lockport. Every Saturday they would bring their eggs and butter into town, where they would be duly exchanged for the necessities of life, in the way of food and clothing.

The farmer's wife used to run the exchange business, but the old man managed to smuggle a dozen or two every trip which he would swap for "toddy."

As he did not have a very good head for drink, he would be very quickly affected, although it could not be discerned from his gait. On this particular day he was in his usual shopping condition; however, his wife desired him to go with her to select some flannel, and as it was for the use of the farmer, she wished his opinion.

The clerk took down a roll, from which he unwound three or four yards, and as the good woman examined it, she said "that seems to be a pretty good quality, but it is too narrow."

The farmer just then took hold of it, and as he unrolled a few more lengths, said, "Mother, it is pretty *narrow*, but, Gee whiz! look at the *length* of it."

It might be said, in passing, that these lathes, which were the longest ever made in this country, have been pronounced by the government experts to be perfect.

THE OBSERVER.

Eckley B Coxe

CASSIER'S MAGAZINE.

VOL. III. DECEMBER, 1892. NO. 14.

THE ELECTRIC SEARCH-LIGHT.

By H. Hutchins, Lieut. U. S. Navy.

ELECTRIC search-lights, important as they are, have been the source of but little literature. While there have been many books written on the subject of electric lighting, this special application of the arc light is rarely ever mentioned; and yet, particularly afloat, the great usefulness of the search-light is fast beginning to be appreciated. This is especially the case with the thousands of moderate-sized steam-vessels that ply on our lakes, sounds and rivers; since in those vessels that are already fitted with them they have been found so valuable, it is safe to predict their general adoption, in such vessels, as well as in coastwise and ocean steamers of the merchant marine. For service in the field, between opposing armies, they are considered invaluable adjuncts, and in naval warfare, whether between opposing vessels, or between marine and land forces, they have already been proved indispensable.

At the present writing the search-light deserves to take rank as the most important of marine electrical applications. To be sure there is a small demand for electric motors on shipboard to replace some of the numerous small steam engines used for auxiliary purposes, and the incandescent electric light has come to be almost a regular fixture in ships for various reasons; but the search-light is doubly important. It is useful in piloting, it gives a means of signalling, it is a necessary weapon in battle at night, and last, but not least, it is frequently the means of saving human life. Truly this is an age of electricity, and nowhere is this fact better exemplified than on board a modern warship, where there is such a variety of applications of electricity, but none more important than the search-light.

As soon as it was realized that the large ironclads were defenseless against torpedo attack, the European powers began experiments with the search-light, and its adoption by the navies of the world is owing to the great development of torpedo warfare. One navy after another made practical tests with it, and in every case it has been shown conclusively that it would be simply impossible for a torpedo boat in clear weather (no fog) to approach undetected near to a man-of-war on board which the light was well handled. The introduction of the search-light, without which no modern warship or torpedo-boat would be considered complete,

dates from 1876. In the English navy the first vessel fitted with a search-light apparatus was the "Minotaur." Some experiments had been carried out in the previous year by Messrs. Wilde & Co., of Manchester, on board the gunboat "Comet," and these proved so far satisfactory that a complete plant was ordered and fitted on board the "Minotaur." The dynamo employed was one of the alternating current type, with thirty-two magnets, and it was driven at about 400 revolutions by a belt from an auxiliary pumping engine. The projector was of a primitive type, and pedestals were fixed in three different places, from any one of which the same projector could be used. It was fitted with a parabolic reflector and with dioptric and diverging lenses. A diaphragm was also provided for enabling flashing signals to be made. The lamp employed was Wilde's and was a vertical one. The carbon rods were square in section, and their holders were made to slide on two pillars, and were moved up and down by a central pillar with a screw-thread cut in it. The lamp was hand regulated, and one lead was put to earth. Mr. Deadman, chief constructor of the Portsmouth (England) Dockyard, further shows the development of the search-light in the English navy up to the present time, in an article written for the "Marine Engineer." The "Temeraire" in the same year was next fitted in a manner similar to that described above, except that a Mangin projector, which has been described in a previous number of this magazine, was introduced, fitted with Wilde's lamp, lens, etc. In the next year, 1877, the "Dreadnought," "Neptune," and several other vessels were fitted with the same class of apparatus.

In 1878 direct driving was first introduced. In this year Messrs. Wilde & Co. coupled their machines to engines made by Brotherhood, and by Chadwick, of Manchester. The dynamo was also improved, so as to be able to maintain two arc search-lights at one time. In the same year also the "Triumph" was fitted by Messrs. Siemens Bros. with a search-light installation. The dynamos were four in number, of horizontal type, arranged in two pairs, and each connected in parallel to one circuit. A switch-board was fitted, for enabling any two of these dynamos to be coupled up together in any circuit. It consisted of a wood base, with two sets of bars at right angles to each other, one set on the top of the base and the other underneath. One set of bars was connected to the dynamos and the other to the circuits. At their intersections these bars could be connected as required, by means of suitable plugs. The projector used was a Siemens' holophote, which was heavy and clumsy, being made largely of cast-iron. It was fitted with diverging and dioptric lenses; of these the latter was composed of concentric glass rings of triangular section, held in a metal frame. It had also a flashing arrangement. The lamp used was one of the Siemens' self-regulating type, and had a small mirror fixed to it. It was complicated and frequently got out of order. The carbons were apt to stick together, and the lamp was sensitive to any slight variation in speed of dynamos. This lamp did not come into general use.

Subsequently the Gramme dynamo was introduced for search lighting by Messrs. Sautter, Lemonnier, of Paris; and in 1881 the "Inflexible" was fitted with this dynamo. In this installation the Mangin projector was used, with a Mangin mirror instead of the dioptric lamps. The lamp was hand regulating and inclined. The Gramme dynamo has since been superseded to a great extent by others of later make; but the Mangin mirror and the inclined hand-lamp survived. The Mangin mirror is now the standard service one in almost every navy of any importance. In the English navy the inclined hand-lamp is still the standard one, while most modern navies have adopted an automatic lamp, which can, if desired, be worked by hand. The lamps used in the French navy and supplied by Sautter, Lemonnier & Co. (now Sautter Harlé & Co.), are of the latter type and

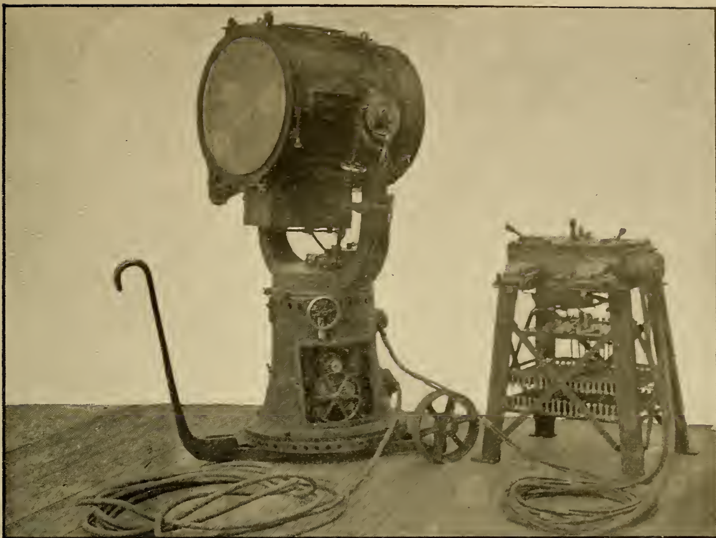


FIG. 1. SEARCH-LIGHT APPARATUS BUILT BY THE GENERAL ELECTRIC CO., NEW YORK.

described in a previous number. Neither has the system of electrically controlling the movements of the projector, which nowadays is considered of so much importance, been yet adopted in England. The firm of Sautter Harlé & Co. have been prominent in applying the system of electrical control to projectors, and their system may be seen in practical use in the French, Italian and Russian navies. The system of electrical control is being fitted to many of the projectors intended for the American cruisers now building, principally for the 60 and 75 c. m. size of projectors. Figs. 1 and 7 give a good idea of these machines as manufactured by the General Electric Co., the automatic lamp for use with them being shown in Fig. 3.

The two most important parts of these projectors for the production of a good and steady beam are of course the reflecting mirror and the carbons. For a long time most navies were dependent on the French manufacturing firms for the supply of these articles, but English and American manufacturers are now entering into competition with the French firms. The French mirrors and carbons, however, are still the standards to which all others are referred.

As regards mirrors, the qualities required are three : first, that they shall project a cylindrical, sharply defined and homogeneous beam of light of great intensity and penetrative power; second, that when in operation they shall not be liable to crack by contact with rain-water or sea-water spray, or by a blast of cold air ; third, that they shall resist the concussion caused by the discharge of heavy guns. These qualities should be combined at a moderate cost if possible, although efficiency is the primary consideration.

The three qualities required in good carbons are that they shall maintain a steady arc without flaming or excessive hissing ; that they shall be perfectly pure and homogeneous in structure, and shall reserve a well formed crater in the

BY PERMISSION OF THE ILLUSTRATED LONDON NEWS.

FIG. 2. SHADOW OF CRUISER THROWN BY SEARCH-LIGHT, AGAINST THE SKY.

positive carbon and a well formed point on the negative ; and that the waste shall be steady and uniform, without cracking or crumbling.

The naval service projector requires, when only hand control is fitted as in the English navy, at least one man close to it, to direct the beam of light in any desired direction, and also to feed and adjust the carbons as necessary. This is a disadvantage, because the position of a search-light is evidently one affording a good mark for an enemy's fire, and is a bad position for observing the object illuminated ; hence, it is now conceded to be an advantage to have the projector entirely manipulated from a protected position at some distance—for instance, from the ordinary conning tower as illustrated by the system of electrical control before mentioned. But this necessitates, first, a good automatic lamp ; and second, an efficient motor for giving the necessary movements to the projector. It is to these points that the English Admiralties are now giving their attention. The projector shown in the figure as manufactured for our new cruisers by the General Electric Co. is expected to give as near perfect satisfaction as the ingenuity of the times will permit. It combines the good features of those that have been produced by the French firms with certain improvements suggested by our Navy Department and the American manufacturing firm. The projector consists of a cylindrical lantern made of very thin steel, with a silvered glass parabolic (Mangin) mirror at the back end, in the focuses of which an arc light is produced between two carbon sticks, held in what is known as an inclined automatic lamp, the carbons standing at an angle of about 20 degrees from the vertical. The feeding of the carbons is automatic as well as the starting of the lamp. These operations can also be done by hand if desired. The feeding mechanism is enclosed in the brass case as shown and is independent of gravity. The coarse wire electromagnet shown in circuit with the carbons, on becoming active, pulls down the lower carbon holder to start the arc. Cored carbons are commonly employed, the upper or positive carbon being the larger of the two, and, being coppered, not only increases the conductivity but preserves a well formed crater. The figure further shows a small fixed reflector secured in position on the rod joining the carbon holders and of such dimensions as to turn back all rays which would otherwise escape from the arc in divergent directions.

The lantern or projector drum is so suspended that it has motion on its pedestal through the whole circle in the azimuth and through about 60 degrees in altitude. While in motion the electrical connections are kept up by suitable rubbing contacts. A main switch and two handwheels are shown on the pedestal for use when working by hand and a handwheel for the motion in altitude is seen on the rod connecting the drum to the gear worked by the electric motor in the pedestal.

The controlling or switchboard used by the operator, which in practice would be some distance away from the light, is shown in Fig. 7. A pair of connecting wires (lead and return) connects the controlling board (with its switch and resistances) to the upper part of the pedestal containing the leads to the rubbing contacts before mentioned ; and flexible leads run from the rubbing contacts to springs pressing on either side of the bottom of the lamp box. The lamp when put in makes contact with these springs and completes the circuit through the carbons. Another cable joins the controlling board with the lower portion of the pedestal, and contains the insulated conductors carrying the motor current for training and elevating.

At the front end of the projector diverging lenses are attached, for spreading the beam over a larger surface when desired. A flashing screen is also affixed for signalling purposes.

In operating these search lights the constant potential system is used. As is the case with ordinary arc lamps, so with search-lights, when the light is fed in parallel with other arcs or incandescent lamps, it is necessary to insert as

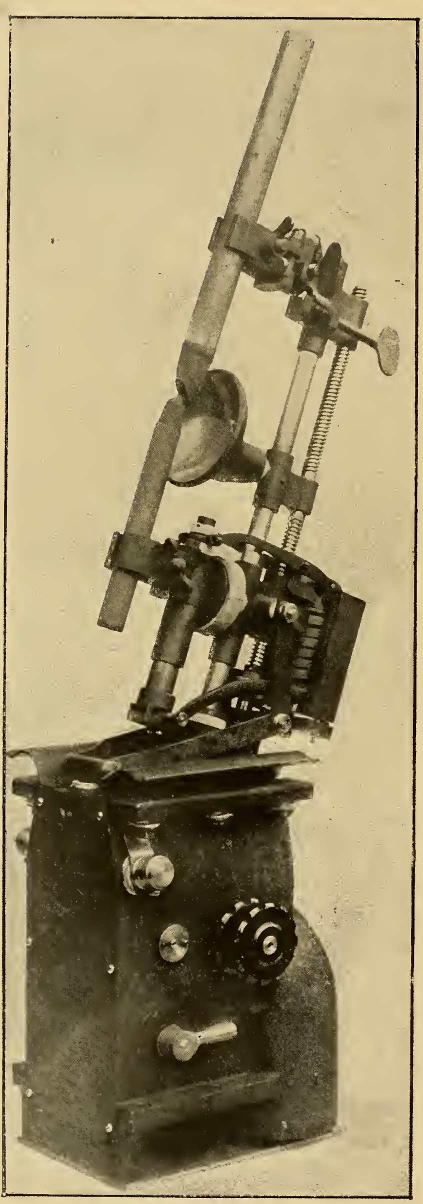


FIG. 3.

much as 15 or 20 ohms in series with each arc to prevent unstable working. Thus a certain amount of waste energy is unavoidable for the proper working of arc lamps in parallel. Although 80 rolls at the dynamo is somewhat higher than is necessary for the search-lights alone, yet other considerations made it advisable to adopt 80 for the standard in our navy when the dynamos are generating energy for the incandescent lamps and motors as well. But in any case the length of time that the search-lights are required to be in operation on board ship is short compared to the time the incandescent lamps are in use, so that the proportionate cost of the waste of energy on account of dead resistance for any extended period, is small.

As regards the amount of light obtained from the projectors, the 60 c.m. projector with a lamp taking 50 to 60 amperes, at 45 to 50 volts, may be said to give a nominal candle power of about 15,000 to 20,000. Since in the arc lights with a direct current, the area of the crater from which most of the light emanates is a rough measure of the current strength, it follows that a lamp taking 100 amperes would give about 36,000 c.p. at the same voltage; the strength of cement and crater area varying in approximately the same ratio as the candle power of the light. The projectors must be made large enough to stand the heat generated. Coming to the arc itself, Prof. Fleming has recently shown that the difference of potential between the positive carbon and the arc flame is about 40 volts, with an arc lamp which operates at 45 volts potential; and the few volts that express the difference between the flame and the nega-

BY PERMISSION OF ELECTRICAL WORLD.

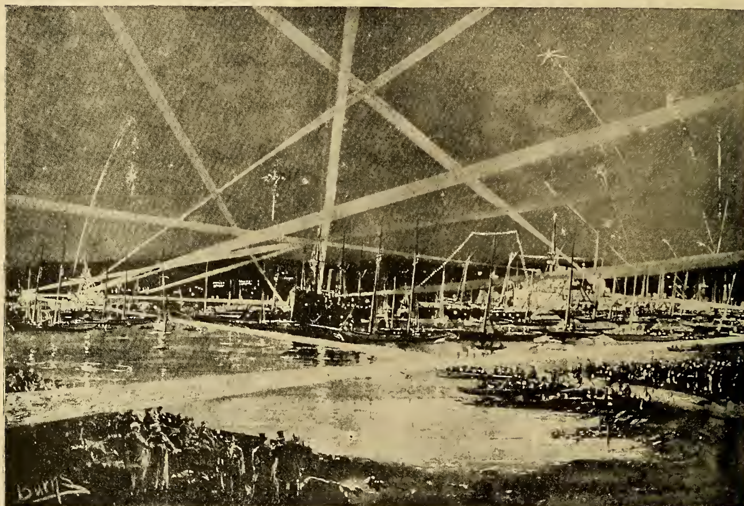
FIG. 4. SEARCH-LIGHT ON TOWER OF MADISON SQUARE GARDEN, NEW YORK. USED BY NEW YORK HERALD FOR SIGNALING ELECTION RETURNS, NOVEMBER 8, 1892.

tive carbon make up the total potential of say 45 volts. Another point of interest in relation to the arc was discovered during experiments at the Thomson-Houston factory. It was shown that the light could be turned out and the arc completely extinguished for a full second, yet when the current was switched on, the arc would be re-established. This was done repeatedly, showing that the hot gas was sufficiently conductive to re-establish the arc, even with such a low potential.

The complete manœuvering of the projector, including the starting and stopping of the lamp, is regulated by the switches on the controlling board. The carbons are kept separated when the projector is not in use, but as soon as the proper switch is closed they are brought together automatically, then the arc is struck and the feeding of the carbons maintained automatically with extreme nicety. In this way one or more projectors are electrically controlled, one man only being required for each, who would be stationed in the conning tower or some other protected position.

Although in naval warfare the search-light is an indispensable weapon of offense and defense, particularly the latter, great judgment is required in using it. For instance, the torpedo-boat being low in the water, her horizon is extremely limited; and more than once, cruisers by keeping their search-lights going at times when the torpedo-boats have merely been reconnoitering, have needlessly disclosed their position to the attackers. On the other hand, when expecting an attack by torpedo-boats, the cruiser's search-lights must be in constant use, and by illuminating the entire circle of the horizon, they form the best means of defense. The torpedo-boats, besides, when blinded by the light, are powerless to manœuvre, in addition to being exposed to the deadly fire of the cruisers' machine guns.

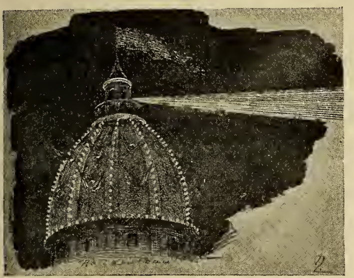
In most navies it is considered neces-



FROM HARPER'S WEEKLY.

FIG. 5. SEARCH-LIGHT ON U. S. CRUISERS USED AT GRAND ILLUMINATION AT NEW LONDON, CONN., AUGUST 3.

sary to fit even torpedo-boats with a search-light. And here again great care is necessary to know when and how to use it. For instance, in a seaway, on account of the lively motion of such a small vessel, it is almost impossible to focus the light upon any object and maintain it there; in fact at such times it would seem only to serve to indicate the position of the torpedo-boat to the enemy. During some experiments with the light on board torpedo-boats in the Spanish navy, the light was at all times so near the water, that it illumined a large expanse of the surface, the confused reflection not only making objects in the illuminated area almost undistinguishable, but quite impossible to see anything beyond. It must be remembered, however, that for navigation purposes, for instance, when reconnoitering the approaches to a harbor, the search-light would be valuable even to a torpedo-boat, so that the fact of its not being always wanted, should not prevent it from being included in the equipment of the boat. It might also be useful in cases where two torpedo-boats were manœuvring conjointly, one using the light and the other taking advantage of the adjoining dark space to make an offensive movement. At all events, it is the present custom in our own and foreign navies to provide torpedo-boats with search-lights. At the bombardment of Alexandria by the British squadron, the search-lights of the latter not only illuminated the harbor, but they also served to keep the British constantly informed of the nightly progress of the Egyptians while erecting their batteries. When engaging at night the search-light is of value in directing the fire of the heavier guns against forts or ships, quite as much as it is in exposing the torpedo-boat to the fire of the machine and rapid-fire guns. It is useful in chasing, and keeping fleets or convoys together, and in reconnoitering a coast. It is useful in preventing collisions, in entering harbors, passing through narrow channels, or going alongside a wharf. It is also useful for distant signaling. Many other useful applications follow as emergencies arise. A few years ago when masted ships were not uncommon, one of the ships of the British flying squadron shifted her foretopmast at night by the electric light of another of the squadron which lay near her; and it is only very recently that the search-lights of the British squadron anchored in Gibraltar Bay were the means of saving hundreds of people from a sinking merchant steamer, many of whom would otherwise have been drowned.



FROM ELECTRICAL WORLD.
FIG. 6. SEARCH-LIGHT ON TOWER OF NEW YORK WORLD BUILDING.

In foggy or misty weather the power of the search-light is seriously crippled, for it has little or no penetration, merely producing a general brightening of the fog. Its use under such circumstances in time of war would only serve to indicate the position of the ship to the enemy.

Many of the naval applications of the search-light cause it to serve obviously a very useful purpose on board both seagoing and inland steamers; in fact, everywhere, the best vessels are not complete without one or more projectors, and, once provided, they should always be kept ready for instant use. During the year 1890, out of a total of 3389 vessels that passed through the Suez Canal, as many as 2836 employed the search-light in order to make the passage by night. Another, and more recent application of the light, for signaling purposes especially, is on board the Providence line of steamers on Long Island Sound. It is brought into play during foggy weather, the beam

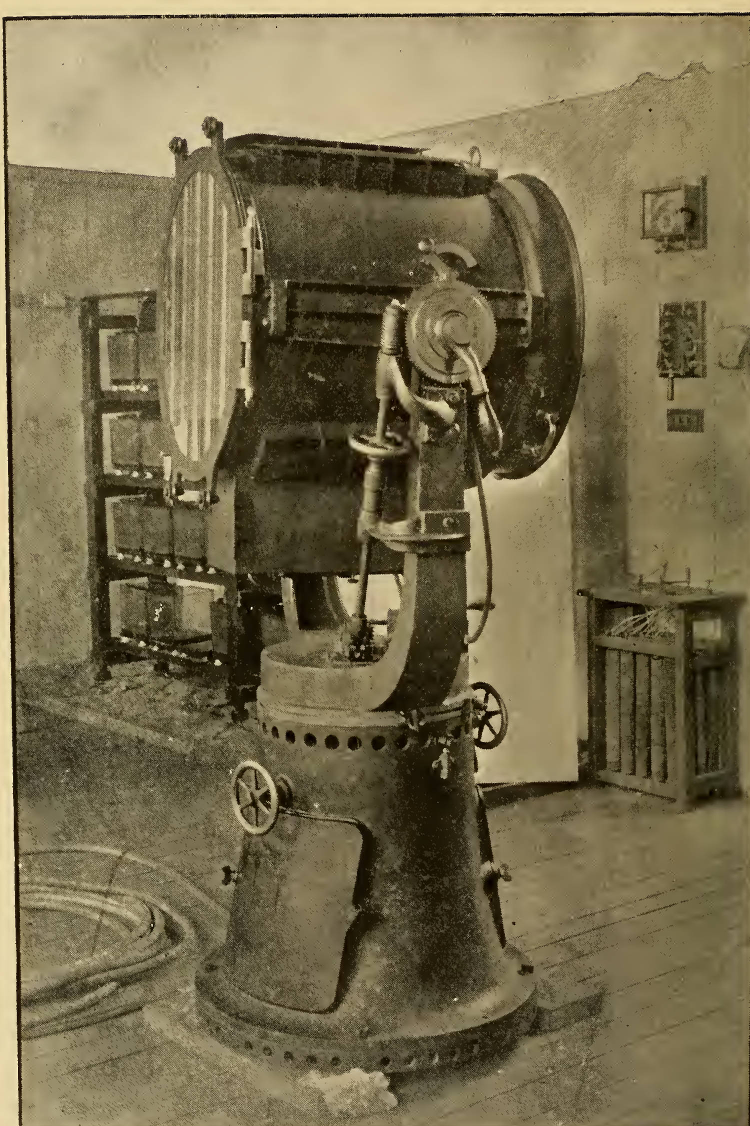


FIG. 7. AUTOMATIC SEARCH-LIGHT.

from the Huntington search-light being thrown directly upwards. In these waters the fogs are said to be, as a rule, not more than 200 feet in height, so that the light once having penetrated this layer reaches the cloud above, its glow being then thrown to an indefinite distance and seen by other vessels, themselves enveloped in fog. In practice the light is flashed perpendicularly, simultaneously with the blowing of the fog whistle.

The portable search-light outfit has been most successfully used in manœuvres and in the Egyptian campaign. It was also used in an African expedition in the gold fields. General Sir Evelyn Wood said that he never went to sleep at night without throwing the light in the direction of the enemy to see if he were moving. Most of the portable generating plants so far manufactured have been too heavy and noisy, but improvement can be expected. Already the weights have been reduced so that a complete machine, with engine and boiler, weighs but from 4500 pounds to about three tons, depending upon the size of the dynamos and engine ; the lighter outfit will furnish a current of twenty-four amperes and forty-five volts at a moderate speed, requiring but about three H. P. of energy. The same carriage carries the projector, a bobbin of double cable and the indispensable necessities of the outfit, such as injector, main pump, tool chest, water tank, etc., etc.

The heavier machine carries the dynamos, engine, boiler, coal and water upon one carriage ; with projector, lamp, two drums of double cable, each 100 metres long, and other necessary apparatus, including a telephone for directing the light from a distance upon another carriage. These wagons weigh about three tons loaded. Each requires four horses. The projector can, if necessary, be dismounted and carried by hand to places inaccessible to the wagon. Steam can be gotten up in twenty minutes.

Pack mule outfits have also been made, no piece when dismounted weighing more than 220 pounds. Great pains have been taken in bringing out the mountain equipment, thus showing its great importance.

Aside from the portable field apparatus the search-light assumes a still more important role when applied to the proper defense of sea coasts, harbors and forts. Each sea coast fort will have to overlook and protect a system of submarine mines and torpedoes. These may and probably will reach to at least beyond mid range for our guns, says Lieutenant Parkhurst, of the U. S. Artillery, a distance that will render all unaided night operations, even with patrol boats, a very uncertain operation. But with a powerful search light, ready to be turned on at any instant, the mine field may be swept in a few moments. Patrol boats will be provided with search-lights also to prevent the enemy from countermining under cover of darkness.

In England preparations are being made on a large scale for the introduction of the most brilliant search-lights for the southern defenses, both sea and land, and to be at the disposal of the artillery stationed in the forts. The projector itself can be in a safe position behind the parapet, the light being thrown on a metallic mirror located above which would be but little injured by a few small bullets, or even a single shot from a rapid fire gun, while a single small arm bullet through the ordinary Mangin mirror would not be so trivial a matter.

In experiments upon the French coast a vessel was picked up at a range of nearly two miles, after which it could be followed in all of its movements, be abandoned and be again picked up with ease. The buoys in the harbor could all be seen, the furthest being one and one-half miles away. The Eiffel tower light in Paris was still more powerful. With a current of 100 amperes and a projector of nearly thirty-six inch diameter it was possible with a good night glass to distinguish the details of objects lighted by the beam at a distance of from four to five miles.

A NEW METHOD OF USING STEAM.*

By Prof. Ewing, F. R. S.

IN December last I carried out a series of trials of Mr. C. A. Parsons' new condensing steam turbine, to determine the consumption of steam under various grades of output. The machine tested was a steam turbine combined with an alternate current dynamo, capable of an output at the rate of 100 kilowatts or 100 Board of Trade units of electrical energy per hour. It was then found that the consumption of steam was 37 pounds per electrical unit when the machine was running under its full load of 100 units per hour, 39 pounds per unit when the load was 50 units per hour, or one-half of the full value, and 43 pounds per unit when the load was reduced to one-third of its full value.

I have now to report the results of a further series of trials, made during the present month, with the object of testing how far the efficiency has been improved by certain recent changes, and by the use of superheated steam. The same turbine was used in these as in the former trials ; but some additional rings of turbine blades were inserted at the high-pressure end, to enable it to deal more effectively with pressures up to 115 pounds per square inch (absolute), the vacuum was improved by the use of a larger air pump and by admitting the injection water at a point of the exhaust pipe closer to the turbine, and there was a new governor. The chief factor in the improvement which has now been brought about is, however, the use of moderately superheated steam. The improvement demonstrated by these new trials is very marked. Thus in the present turbine, with steam superheated 60 degrees Fahrenheit above the temperature of saturation, the gross amount of feed water is 28.4 pounds per electrical unit generated when the machine is working at full load, and 32 pounds per unit at half load. By carrying the superheating further (to 123 degrees Fahrenheit above saturation), the consumption at full load is reduced to 27 pounds per electrical unit. Comparing these figures with those of the former trial, it will be seen that the consumption of steam has been reduced by about 27 per cent. What makes these results specially important is the consideration that there is nothing in the construction or working of the turbine to make it likely that the use of superheated steam will be attended by any drawbacks such as have been experienced in engines of the ordinary type. The steam works without lubrication, it comes into contact with no rubbing surfaces, and there is no packing to be injured.

A general view of the plant tested is given in elevation in Fig. 1 and in plan in Fig. 2. The turbine case *a a* contains a series of seven revolving discs, from the surface of which the turbine blades project. They are arranged on each disc in a series of concentric rings. The fixed guide blades stand in spaces between these rings, being carried by annular discs which are fixed to the case. Thus each revolving disc, with its neighboring fixed disc, forms a series of outward-flow turbines, the steam entering the series inside the smallest ring of blades and escaping at the circumference into a channel, which conducts it between the back of the revolving disc and of the next fixed disc to the inside of the next series of rings. The arrangement will be understood by reference to Fig. 3, which is a section showing the first three turbine discs. The heights and apertures of the turbine blades on each disc are adopted to the increasing volume of the steam as it ex-

* Report on trials made under the direct supervision of the writer.

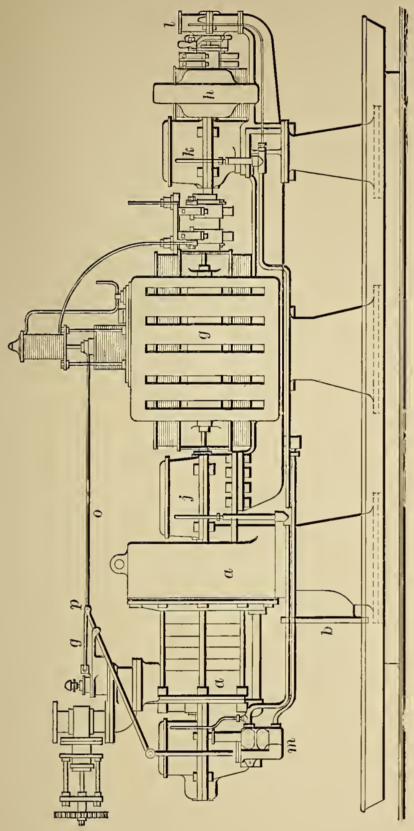


FIG. 1.

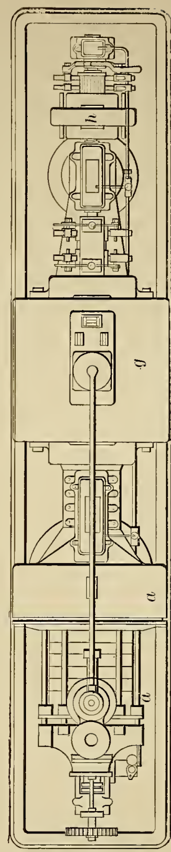


FIG. 2.

pands from an absolute pressure of 115 pounds per square inch to an absolute pressure of 1 pound per square inch. The first six discs, which are each 15 inches in diameter, are designed to expand the steam to about atmospheric pressure, the remainder of the expansion being performed in passing the seventh disc, which is 26¾ inches in diameter, and has (unlike the other six) a double series of rings of blades, one series on each side, through which the steam flows, "in parallel." The height to which the turbine blades project above the discs in which they are secured varies from 3-16 inch to 1 inch. The whole number of rings of moving blades in the machine tested was 35. The blades are made of strong sheet brass, and show no sign of wear after continued use. Steam enters the turbine case at one end through a double-beat valve, shown in Fig. 3, and after passing the successive turbine discs is discharged at *b* (Fig. 1) to a condenser. The longitudinal pressure on the turbine

shaft, due to the one-sided character of the six smaller turbine discs, is balanced at the high-pressure end by a revolving baffle piston (Fig. 3), with a number of deep grooves on its circumference, which are entered by corresponding projections on a fixed bush resembling a thrust block. Any small amount of longitudinal thrust which may remain unbalanced is received by an adjustable grooved thrust bearing at the end of the spindle, beyond the main bearing. This, which is contained in the oil box *c* (Fig. 3), is shown to a larger scale in section in Fig. 4. The thrust bearing (Fig. 4) consists of seven collars on the spindle revolving in a grooved bush, which is split longitudinally into halves, with separate longitudinal adjustment to allow any wear to be taken up, so that end shake is prevented, and the endwise position of the shaft is maintained with great precision. This device also gives a means of regulating the amount of clearance over the tips of the turbine blades. The thrust bearing, like the main bearing, runs in a bath of oil.

The main bearings are of a special construction, which is admirably adapted to ensure easy running at a high speed, and to damp out vibration. The shaft Fig. 4 rotates in a phosphor-bronze sleeve, outside of which are slipped three concentric steel tubes fitting loosely over one another. The outermost tube (Fig. 4) is a loose fit in the casting, which forms the seat of the bearing. Oil is continuously and freely fed to the bearing from a cistern above, under a head of some six inches, and drains into a chamber below, from which it is automatically pumped back to the cistern. The oil is used over and over again. In this way the small clearance between each tube or sleeve and the one outside of it are kept charged with a film of oil, with the effect that, while the shaft retains a necessary small amount of freedom to adjust itself by lateral displacement, the viscosity of the films acts as a powerful damper to prevent oscillation from being set up. The working of the bearing is perfectly satisfactory, and the damping action is so great that the shaft may even be put considerably out of balance without causing the vibration to become excessive or making the bearings run hot. In the ordinary conditions of balance the shaft carrying the turbines, the main armature, and the exciter armature runs at eighty revolutions per second, with a steadiness

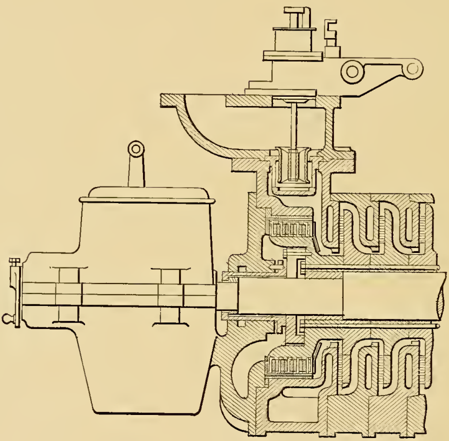


FIG. 3.

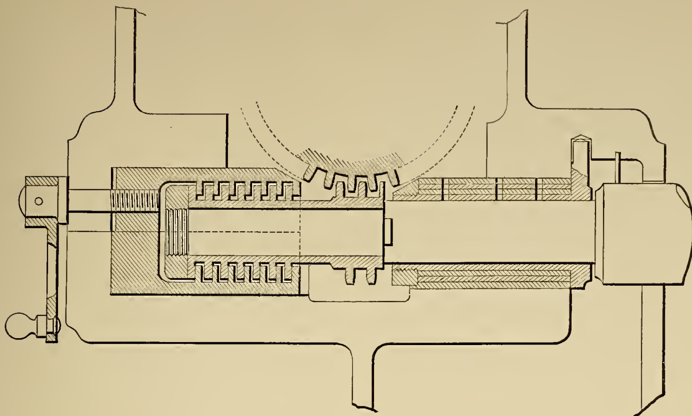


FIG. 4.

and quietness which are most remarkable.

The shaft passes out of the turbine case at each end through a lantern brass or steam gland. The whole shaft is in three lengths; the first part carries the turbines, the second carries the armature of the main dynamo *g* (Fig. 1), and the third part that of the exciter dynamo *h*. The parts are coupled by means of a square-bored sleeve slipped over squared ends. The couplings are placed in the middle of long double bearings at *j* and *k*. These, as well as the end bearing at *l*, are all formed by concentric tubes, and work drowned in a sea of oil, as already described for the end bearing. The oil chambers are connected by pipes, so that a single oil pump maintains the circulation in all. The pump, which is shown at *m* in Fig. 1, is driven by an eccentric, which receives its motion from a worm *n* on the main shaft, working in oil, between the main bearing and thrust bearing of Fig. 4.

The governing of the machine tested was accomplished by a novel and extremely effective appliance. Steam was admitted to the turbine in a series of gusts by the periodic opening and closing of the double-beat lift valve shown in Fig. 3. This valve was operated by means of a steam relay in mechanical connection with the turbine shaft, so that the valve was opened regularly once in every twenty-eight revolutions of the shaft. The duration of each gust was controlled by an electric solenoid, which was connected as a shunt to the field magnets, but was compounded so as to keep the volts constant. The core of the solenoid was hung from the end of a long lever *o*, Fig. 1. The fulcrum *p* of this lever was periodically moved up and down by means of a link connecting it with the eccentric, which also served to drive the oil pump. The short end of the lever *q* controlled the valve of the steam relay. Each periodic movement caused a gust of steam to be admitted to the turbine, the duration of the gust depending on the height of the distant end of the lever. The effect was, that at full load the gusts became blended into an almost continuous blast, the lift valve closing only momentarily, or not at all, in each of the periodic movements; under any lighter load each interval of admission alternated with an interval during which the steam was completely shut off. The action of the governor was most satisfactory. The periods of admission were so frequent that they caused no material throbbing of speed

nor any variation of volts sensible on a voltmeter. There was no hunting, and the freedom from friction was greater than I have seen in any governor. I repeatedly threw the whole load, amounting to over 130 electrical horse-power, on and off suddenly, without causing more than a momentary variation in the volts. The governor was sensitive, quick, and certain in its action to quite an exceptional degree.

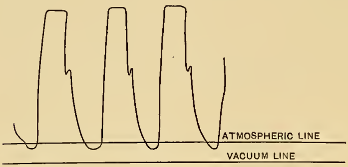


FIG. 5.

By applying an indicator at the admission end of the turbine chamber, below the double-beat valve, observation was made of the pressure during the periodic admission of steam ; this was done by pulling the paper drum of the indicator as steadily round as possible by hand while the pencil rose and fell. Figs. 5 and 6 are examples of diagrams obtained in this way. In Fig. 5 the load was about one-half the maximum ; in Fig. 6 it was about three-quarters. The pressure which these diagrams show during admission is about 4 pound less than that shown at the same time by a pressure gauge on the steam pipe above the governor valve.

The machine tested was primarily constructed to generate alternate currents up to 50 amperes, with a potential of 2000 volts, and in some of the trials the original alternate-current armature was used. But thinking it desirable to make the tests of efficiency depend on measurements of continuous rather than of alternating currents, in order to avoid any uncertainty which may be held to attach to estimates of the work spent in an alternate-current circuit, I suggested to Mr. Parsons the desirability of winding a continuous current armature specially for these trials. He adopted the suggestion, and most of the trials have accordingly been made with a continuous-current armature, wound to give 400 amperes at 250 volts. The original exciter was still used to supply current to the field magnets.

It may be said at once that the results of the continuous-current trials, where the electrical measurement of the work done is of a perfectly simple and straightforward character, are in close agreement with those of the alternate-current trials.

The main armature was about 2 feet 6 inches long over the body, by 9 inches in diameter. The weight of copper on it was only 33 pounds or ⅓ pound per kilowatt of output.

Steam for the turbine was supplied at a pressure of 100 pounds per square inch by gauge, from a locomotive boiler which was capable of giving enough for the full load of 100 units per hour. The feed water was measured by putting it through a tank, the graduations and total capacity of which I checked by weighing water into it. The contents of this tank were delivered into a second tank, from which the feed pump drew its supply, and in which the level of the water was adjusted to have the same value at the beginning and end of each period of observation. The level of water in the boiler was kept as nearly as possible constant throughout.

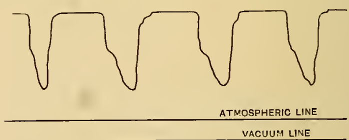


FIG. 6.

In all the statements which follow of the results of these trials the quantity of feed water named is the gross quantity supplied to the boiler, no deduction having been made for leakage, blow-off at the safety valve, or other loss.

On its way to the turbine the steam

passed through an improvised superheater, consisting of eight 9 feet lengths of cast-iron pipe, 8 inches in internal diameter. This superheater was placed in the main boiler flue, and, except in a special series of trials noted below, was heated merely by the hot gases from the boiler tubes. The draught was forced by a steam jet from an auxiliary boiler. Notwithstanding the small size of the improvised superheater, this sufficed to bring the steam from 338 degrees Fahrenheit, the temperature of saturation, to about 400 degrees Fahrenheit. In a special series of trials extra superheating was produced by lighting a furnace built for that purpose in the brickwork enclosing the superheater. With the help of this furnace, the temperature of the steam in these special trials was raised to about 465 degrees Fahrenheit.

Three separate sets of trials were made, August 11 to 15, 1892. In the first set the steam was superheated by means of the hot gases from the boiler furnace only. The temperature approached but did not exceed 400 degrees Fahrenheit, which, as the boiler pressure was 100 pounds per square inch above the atmosphere, corresponds to about 60 degrees of superheating. In this set of trials the continuous current armature was used, and the amount of feed water was determined for six different grades of output, from no electrical load up to a load in which the output was at the uniform rate of 102 Board of Trade electrical units per hour, the current being spent on a bank of coils. The results of this set of trials are set forth in Table I. The output stated is the amount of electrical work done upon the external circuit, and does not include the output of the exciter. The volts were measured by three Cardew voltmeters, which were tested against each other, and one of them against a Thomson balance. The amperes were measured in the following way: A low-resistance frame consisting of many bare thick wires of platinoid, grouped in parallel, was arranged as a shunt to a mirror galvanometer, which was provided with a strong controlling magnet, so that the whole current of about 400 amperes could pass without causing an inconveniently great deflection, and without heating the wires of the shunt materially. In series of this was placed (1) an Evershed amperemeter which had been carefully calibrated by reference to a Thomson balance, and (2) two Siemens electro-dynamometers, one of which could take the strongest current, while the other was suitable for comparatively weak currents only. The constant of the shunted mirror galvanometer was determined in the low-power trials by comparing its deflection with the readings of the Evershed and of the more sensitive of the two Siemens' instruments. These were then cut out to allow stronger currents to pass, and in the trials under heavy load a further check on the constant of the mirror galvanometer was furnished by the readings of the larger electro-dynamometer. The mirror galvanometer, the constant of which remained unaltered throughout, served to connect the readings of all the currents, from the lightest to the heaviest loads. The agreement between the various measurements was perfectly satisfactory.

In the second set of trials the object was to test the effect of additional superheating. A special furnace, built into the up-take of the boiler flue, was made to give additional heat to the superheater, forcing the temperature of the steam to 465 degrees Fahrenheit. In this set of trials the continuous-current armature was again used, and the measurements were made in the same way as in the first set. Three different grades of output were tested. The results are given in Table II.

In the third set of trials the alternate-current armature was used, giving 2000 volts at a speed of 4800 revolutions per minute, which made the frequency of alternations 80 periods per second. Here the current was directly measured by the Evershed and Siemens' instruments, and the volts were determined by (1) a Cardew voltmeter furnished with a resistance specially wound to enable it to read 2000 volts, and inde-

pendently (2) by another Cardew voltmeter with a step-down transformer having a ratio of one to twenty. The output was taken to be the product of the effective volts and the effective amperes. In these alternate-current trials the electrical energy was absorbed by a water resistance formed by sticking two rods, to serve as terminals, some ten yards apart in a pond, the amount of resistance between them being adjusted by pulling the rods out or in to expose more or less of their surface to contact with the water. In this third set of trials the steam was moderately superheated, as in the first set, by the hot gases of the boiler flue only—its temperature again approaching 400 degrees Fahrenheit. The results are given in Table III. The close agreement of them with the corresponding continuous-current trials (Table I) is important, as supplying evidence that in alternate-current trials conducted in this manner the effects of lag in the external circuit are immaterial; in other words, that the electrical work is properly measured by multiplying the effective volts by the effective amperes. The difference between the alternating and continuous-current measurements is less than 1 per cent. of the output at full load.

In each of the trials the turbine was kept running for a sufficient time beforehand to establish a nearly uniform regime, and the trial was kept up long enough to prevent any material error from coming in through inexact readings of the water level in the boiler gauge glasses. In each trial, the amount of the feed water was determined during two successive equal periods of time, to test the agreement of these with each other. The air pump and feed pump were driven by donkey engines, the steam for which was supplied from a separate boiler, and is not included in the figures given below. What the tables give is the gross amount of feed water actually delivered to the main boiler, from which the whole supply of steam for the turbine was drawn.

The temperature of the steam was read by a thermometer placed in a mercury pocket in the steam pipe, close to the turbine. A pressure gauge placed there showed that the pressure was, at full load, between 2 pounds and 3 pounds per square inch less than the pressure at the boiler. The amount of super-

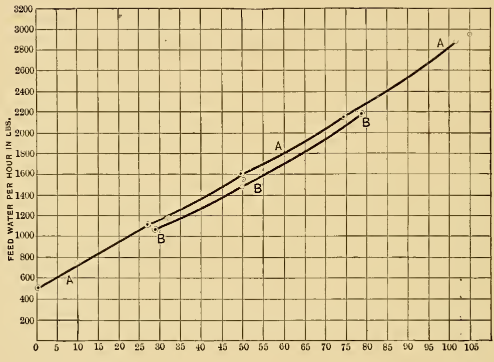


FIG. 7.—Trials of Parsons' Steam Turbine and Dynamo, August, 1892.

AA.—Steam superheated to about 400 deg. Fah.; continuous current trials ⊙: alternating current trials ×.
B B.—Steam superheated to 465 deg. Fah.: continuous current trials.

heating in the trials of Table I was comparatively small under light loads, because the boiler fire was not then being forced; from half load to full load it was nearly uniform.

The results are also exhibited in the curves, Figs. 7 and 8. The rate of electrical output is shown in relation to the whole consumption of feed water per hour in Fig. 7, and in relation to the consumption of feed water per electrical unit in Fig. 8. The line A A in each diagram refers to the first set of the present trials—those of Table I—which were made with continuous currents and moderate superheating. The points of observation are marked thus ⊙. The points marked ×, which lie very close to this curve, and a trifle below it, are for the tests made with alternating currents (Table III).

The line B B in each diagram relates to the trials with extra superheating (Table II). The points of observation are marked thus ⟍.

To facilitate comparison, the amount of feed water used per electrical unit at various rates of output, as measured from the curves of Fig. 8, is given numerically in Table IV.

The trials show that a very considerable advantage is realized by moderate superheating. To superheat the steam from, say, 338 degrees Fahrenheit, the temperature of saturation for a boiler pressure of 100 pounds to 400 degrees Fahrenheit requires the addition of barely 30 units of heat, which is less than 3 per cent. of the heat taken up in the boiler. With steam superheated to this extent the consumption of full load is less by one-fourth than the consumption in the old trials. How much of this increase in economy is due to superheating alone cannot well be distinguished without further trials, as the comparison is complicated by the other improvements

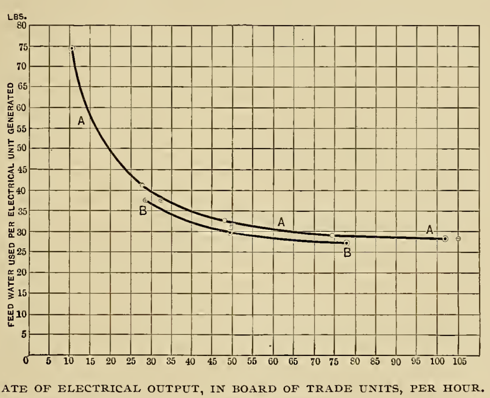


FIG. 8.—Trials of Parsons' Steam Turbine and Dynamo, August, 1892.

AA.—Steam superheated to about 400 deg. Fah.; continuous current trials ⊙; alternating current trials ×.
B B.—Steam superheated to 465 deg. Fah.; continuous current trials.

Table I.—Trials with Continuous-current Armature, with Steam Superheated by the Gases from the Boiler fire only.

Pressure by Gauge on Boiler.	Temperature of Steam.	Load in Electrical Units per Hour.	Feed Water per Hour in Pounds.	
lb. per sq. in.	Deg. Fah.		Total.	Pr unit.
96	335	0.1	480	—
102	565	10.2	760	74.5
100	356	27.0	1110	41.1
102	400	49.2	1590	32.3
100	390	74.5	2170	29.1
103	398	102.0	2900	28.4

Vacuum in full-power trial: By mercury column at exhaust, 27½ in.; by gauge on condenser, 28½ in.; barometer, 29.9 in.; temperature of injection water, 73 deg. Fah.; speed, 4500 revolutions per minute.

Table II.—Trials with Continuous-current Armature with Extra Superheating.

Pressure by Gauge on Boiler.	Temperature of Steam.	Load in Electrical Units per Hour.	Feed Water per Hour in Pounds.	
			Total.	Pr unit.
lb. per sq. in.	Deg. Fah.			
102	463	28.3	1060	37.5
102	468	49.5	1480	29.9
101	465	78.4	2170	27.7

Vacuum by gauge on condenser, 28¼ in. Barometer 29.5. Temperature of injection water, 72 deg. Fah.

Table III.—Trials with Alternate-current Armature and Water Resistance: Superheating by the Gases from the Boiler Fire only.

Pressure by Gauge on Boiler	Temperature of Steam.	Load in Electrical Units per Hour.	Feed Water per Hour in Pounds	
			Total.	Pr unit.
lb. per sq. in.	Deg. Fah.			
99	367	31.6	1180	37.3
97	394	49.9	1550	31.1
103	399	105.2	2970	28.2

Vacuum in full-power trial: By mercury column at exhaust, 27½ in.; by gauge or condenser, 28¼ in.: barometer, 29.6; temperature of injection water, 72 deg. Fah.

Table IV.—Consumption of Feed Water at various Rates of output, with Superheating.

Rate of Output in Electrical Units per Hour.	Feed Water per Electrical Unit.	
	With Superheating to about 400 deg. Fah.	With Extra Superheating to 465 deg. Fah.
20	48	
30	39	36½
40	34½	32
50	32	29½
60	30½	28½
70	29½	28
80	29	27½
90	28½	(27)
100	28½	(27)

referred to at the beginning of this report. It is clear, however, that superheating is responsible for a great part of the difference. Apart from the increased volume of the working substance the advantage of superheating is to be ascribed in part to the prevention or reduction of the condensation at entry, which would otherwise take place in consequence of the intermittent character of the admission, and in part to its influence in keeping the steam dry during its expansion, and thereby reducing the internal resistances. At full load, when the steam enters in a nearly continuous blast, the latter effect is no doubt the more important.

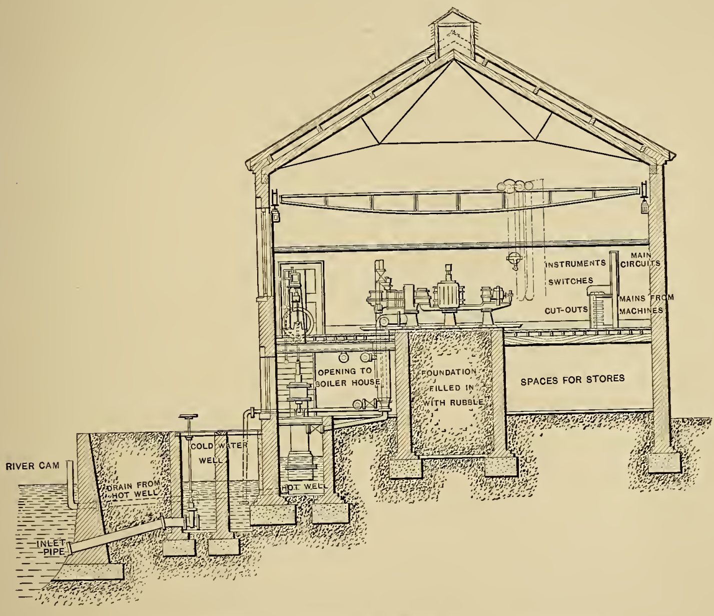
The further advantage realized by superheating to 465 degrees Fahrenheit is comparatively small, especially at high loads. From evidence given by the temperature of the turbine case, it was clear that this amount of superheating not only kept the steam dry throughout its whole course through the turbine, but left it still considerably superheated at the end. The part of the case next the exhaust, which had been quite cool in the trials of Table I, was decidedly hot in those of Table II. This observation agrees with the result of calculation, which shows that an initial temperature of above 442 degrees Fahrenheit would be high enough to prevent the steam from becoming wet as it expands.* It may be concluded from this consideration, as well as from the results of the trials, that very little increase of efficiency is to be brought about by carrying the superheating further than this. It seems, therefore, undesirable to push the superheating to a higher point than can readily be reached by the use of a superheater in the boiler flue. With a superheater of moderate size the hot gases of the uptake will furnish as much superheating as need be aimed at, and as much as is sufficient to secure highly economical working.

The general result of the trials is to demonstrate that the condensing steam turbine is an exceptionally economical heat engine. The application to it of moderately superheated steam has put the performance of the turbine on a level with that of the best steam engines of the ordinary type. A consumption of 27 pounds or 28 pounds of steam

* Taking the initial pressure as 115 pounds per square inch absolute, the temperature of saturation is 338 degrees Fahrenheit. Superheating to 443 degrees Fahrenheit makes the total energy of each pound of steam at admission 1235 thermal units. Each pound does work equal (at full load) to about 1-28th of an electrical unit, and the thermal equivalent of this is 122 thermal units. Hence, if we neglect the small loss of heat which occurs through radiation and air conviction from the turbine case, steam at 100 pounds pressure initially superheated to 443 degrees Fahrenheit will retain at exhaust a total heat of 1113 thermal units. This makes it just saturated, for 1113 thermal units is the total heat of 1 pound of saturated steam at the final pressure of 1 pound per square inch.

per electrical unit at full load, and 30 pounds or 32 pounds at half load, is a result that does not need to have its significance emphasized. The efficiency under comparatively small fractions of the full load is probably greater than in any steam engine, and is a feature of special interest in relation to the use of the turbine in electrical lighting from central stations.

The consumption of 28 pounds per unit corresponds to 20.9 pounds per that is to say, the work done without useful output—was equivalent to 27 kilowatts, or 36 horse-power. The effective work at full load, the equivalent of 100 electrical units per hour, was 134 electrical horse-power. Hence, if the idle work had the same value at full load as when the machine was running light, the total work done by the steam at full load would be 170 horse-power, and the effective work (134 horse-power) would be 79 per cent. of the



PLAN OF ELECTRIC LIGHT STATION. OPERATED BY STEAM TURBINE.

electrical horse-power hour. To facilitate comparison with other engine trials, it may be useful to estimate from these results what may, by analogy, be called the "indicated" horse-power of the turbine—that is to say, the mechanical work done by the steam on the turbine blades. The curves of Fig. 7 are nearly straight lines, and by prolonging them backwards to meet the base line produced, it appears that the idle work— total. But the idle work certainly increased when the machine was loaded, and it will be nearer the truth to assume that the effective work was not more than 75 per cent. of the total work. This would make the total work about 179 horse-power. On this basis, a consumption of steam at the rate of 28 pounds per electrical unit is equivalent to 15.7 pounds of feed water per "indicated" horse-power hour, and

27 pounds per unit is equivalent to 15.1 pounds per "indicated" horse-power hour. Similarly, the consumption of half load is equivalent to about 17 pounds per indicated horse-power hour.

No allowance, as has been said, was made in these trials for leakage of steam and water from the boiler. It is well-known that some leakage occurs under the most favorable conditions, and that if the quantity of steam used were measured after passing through the engine—as is often done in tests where a surface condenser is used—the results would be more favorable than those obtained by direct measurement of the feed. In the present instance it appeared (from separate observations) that the losses by leakage amounted to about 90 pounds per hour, or, say, 3 per cent. of the whole consumption in the full power trials, If this allowance were made, the quantities of steam per horse-power hour and per unit would be reduced below the values stated above by about 3 per cent. in the full-power trials, and by about 6 per cent. in the half-power trials.

By applying the indicator at various parts of the turbine case, the range through which the pressure varies as each gust of steam passes, and the fall of pressure from one set of turbine rings to the next throughout the series, may be examined. This was done during the trials, with the result of showing that the apertures of the several turbines were not adjusted in the best possible relation to one another ; in particular it was found that the turbine rings on the large disc at the condensing end gave too free a passage, and were doing less than their proper share of work. The readjustment of areas indicated by this test as desirable will, no doubt, secure even better results.

Apart from the other possible applications of a peculiarly light and efficient high-speed motor, the turbine dynamo in its present state is, in my opinion, eminently well fitted for central station use, not only on account of its economy of steam under both heavy and light loads, but also on account of its exceptional lightness and compactness, its small first cost, its independence of foundations, its freedom from vibration, its steady governing, its simplicity, the ease with which it is handled, and the moderate outlay which it may be expected to require under the heads of maintenance, oil and attendance. So far as I have been able to judge, the performance of the machine is as excellent as its details are ingenious.

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Second Paper.

THE strong impetus of ambition, with the sense of conscious power, came, and Edison bent his energies towards obtaining the successful control of a "report" wire, the mastering of which bid fair to open avenues of increased influence and remuneration. He attained his end through the assistance of a fellow operator, a lad of kindred taste and aims. Together the confederates worked and consulted with all the delicious mystery of inquisitorial familiars, and by the adjustment of two recording registers, the one for the reception, the other for the repeating of the embossed writing, they succeeded in obtaining "reports," remarkable for their perfect accuracy and clearness. The manager, on being diplomatically approached, was induced to give the lads a trial of skill, and was so delighted with the results submitted, that he engaged the confederates for several weeks to supply the "copperplate transcriptions." At first the system worked smoothly and no delays were occasioned, but at the end of that time an unusual pressure of telegraphic matter made it impossible for the automatic repeater to keep pace with the despatches, and the numerous complaints from newspaper offices which were laid before the manager next morning, resulted in that gentleman's personal investigation, a prompt suppression of the secret measures employed, and a summary discharge from the office. Thus for lack of discrimination, the Indianapolis office was deprived of what, under certain judicious restraints, would have proved the highest order of skill and industry. These attributes were brought into early requisition during an engagement at Cincinnati, where he worked as day operator at a salary of $60 a month, supplementing his labors by night practice, whenever he could obtain the use of the wire.

One day a delegation of Cleveland operators descended on the Cincinnati office, with intent to found a local branch of the telegrapher's union. From time immemorial it has been customary to stimulate the flames of brotherly unity by copious alcoholic libations, and the Christian world has progressed little since the days when the Roman calendar was based "upon the foreign priest and the foreign cook." Edison's fraternal feelings were sufficiently genuine to be independent of this carnal basis, and being then what he is now, a scrupulously abstemious man, he discarded the company of Bacchanalian revelers for the more congenial surroundings of the office. Not a soul was to be seen but the office boy. The Cleveland wire imperatively demanded "report," but none was forthcoming, until at length, after an hour's irresolution, Edison supplied the gap, manipulating the wire with his usual practiced skill. At eight the next morning he was in his accustomed place, despite the severe and protracted labors of the night.

Edison endeavored to suppress the irregularities of his friends together with his own timely exertions—a secrecy which speaks volumes for his sense of honor and kindliness of heart, but the

* Began in November issue.

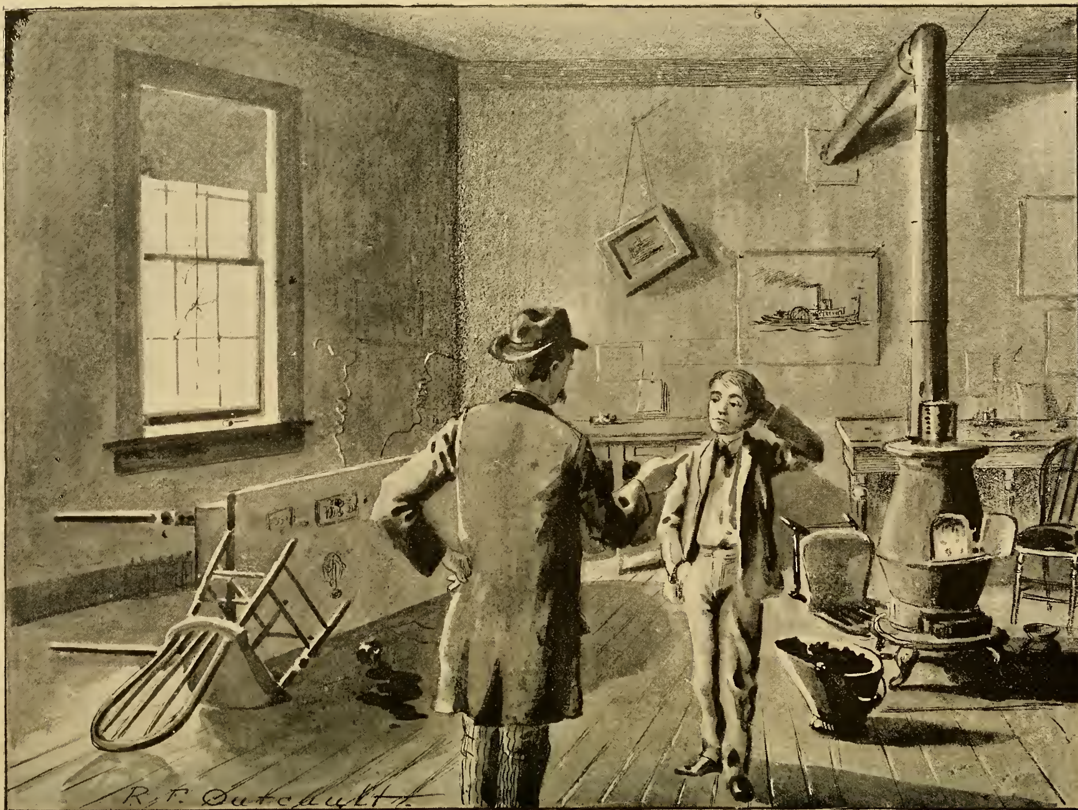
office boy divulged the facts, securing to the young operator not only the lasting favor of his employers, but an increased salary of one hundred and five dollars. The Louisville wire, an important section, carrying all the Southern reports and necessitating expert skill, was placed in his hands, and Edison sustained a brisk competition with the Louisville operator, Mr. Robert Martin, a gentleman renowned for rapidity and clearness of transmission. To this advantageous partnership he attributes the final fruition of his abilities.

Memphis, Tennessee, was his next move. Here the operators received $125 a month and rations, counterbalanced by the fact that they were under the most stringent military law. Edison's abilities either won respect or excited a rancorous envy, according to the class of individual with whom he had to deal, and in the present instance he was unfortunately thrown with a manager incapable of generous appreciation and jealous of rising talent. This liberal-minded gentleman was endeavoring to perfect a repeater of his own invention at the time of Edison's arrival, but his efforts had been hitherto fruitless. Edison, with characteristic energy, commenced experiments at once, which were crowned with success, and in consequence of which Louisville and New Orleans were connected, for the first time in the annals of telegraphy. This turn of events so enraged the manager that he brought a fictitious charge against his rival, which resulted in the latter's dismissal. This was a serious misfortune, and befell our hero at a time when he was ill prepared to be thrown on his own resources. Such portions of his salary as had not found their way home, had long ago been transmuted into books and instruments, and his wardrobe was in the last stage of destitution. His health, too, was beginning to feel the strain of his sleepless nights and protracted labors, and altogether he was a better subject for motherly coddling than for the rude experience which lay before him. But the indomitable spirit within refused to yield to the forces arrayed against it, and this seventeen year old lad, feeble, penniless and sore-hearted, actually conceived and carried out the plan of reaching the city of Louisville, walking one hundred miles, and obtaining free transportation for the remainder of the distance. At Nashville he was joined by a fellow operator, one William Foley, a lad of shady reputation but good heart, and together the two boys pursued their journey, arriving at their destination one bleak and cheerless morning, toward the beginning of winter. The church bells were clanging the hour of six, and the great city, with its ice-locked streets, seemed the external projection of the colder hearts within its gates. Nothing more desolate can be conceived than the figure of this slender, eager-eyed lad, stranded on the margin of this desert, faint with hunger and fatigue, paralyzed with cold, and disheartened with injustice and rough usage. The support, accruing from costly attire, was lacking, and Edison was now sufficiently a citizen of the world to know that his unprepossessing exterior far outweighed any mental or moral qualifications. "Is it not to clothes that most men do reverence—to the fine, befrogged broadcloth?" Soleless shoes clung fragmentarily to his aching feet, a straw hat covered his head, thin summer underwear mocked the searching blasts, and a miserable linen duster threw its poor protection over the stained and threadbare raiment. That vacuum, which nature so cordially abhors, was visible in his pockets, and a handkerchief, suspended over his shoulders, carried the bulk of his worldly gear. In this humble fashion he presented himself at the telegraph office, where he was distrustfully and superciliously received. Gradually, however, the tests of skill which he submitted to the manager, backed by his bright and earnest manner, won their way to public approval, and he was installed as operator, a position which he retained for two years, despite the most uncongenial surroundings. The employees were vulgar, unprincipled and overbearing, and disposed to ridicule their rustic associate.

In course of time, however, Edison's kindness of disposition, his innocent and studious life, and his phenomenal abilities disarmed their prejudices and commanded their respect. Edison's mind was upset about this time by certain tantalizing reports relative to the marvelous resources of Southern America, and, in conjunction with two of his friends, Messrs. Keen and Warren, he started on his quest. His mental balance was fortunately restored upon his arrival at New Orleans, where he met an ancient and traveled Spaniard who persuaded him to return to his native clime, averring that for government, institutions, climate and people the United States were unsurpassed by any country on the face of the earth. A brief but pleasant visit to his relatives in Port Huron followed, after which Edison resumed his work at the Louisville telegraph office. True to his dominant instincts, he was not long in gathering around him a laboratory, printing office and machine shop. He took press reports during his whole stay, including on one occasion the Presidential message and veto of the District ot Columbia by Andrew Johnson. This at one sitting, from 3.30 P. M. to 4.30 A. M. He then paragraphed the matter received over the wires, so that each printer had exactly three lines, thus enabling a column to be set up in two or three minutes' time. For this he was allowed all the exchanges he desired, and the Louisville press gave him a state dinner. (These and the subsequent facts were secured during one of Mr. Edison's comet-like progressions through the laboratory, and may serve to supplement the meagre information at the public's disposal.) "I began," continues Mr. Edison, "to frequent second-hand book stores and acquired quite a library. There was to be a contest for fast sending amongst the telegraphers. I was comparatively poor at sending, but a first-class receiver. I therefore rigged up an automatic machine whereby I could record the matter very slowly and perfectly, and then reproduce it at any increased speed. Unfortunately the tournament did not come off, or I should have been the winner. The Louisville office was during and at the end of the war in a very dilapidated condition, and the management was correspondingly lax. One night when I was taking reports I heard a tremendous noise on the stairs, and there appeared at the door one of the most skilled operators in the force, a man whose splendid abilities were crippled by his habitual drunkenness. He was now in one of his most violent fits. He hesitated an instant, then walked in, kicked over the stove with its long length of sooty stovepipe, then proceeded to pull down the switchboard and yank all the operating tables away from the side of the wall, piling their instruments and all on the top of each other. Then he proceeded to the battery room, where he pulled down the shelves with their contents, upsetting a bottle of nitric acid, which ran through the ceiling to the office below, eating up the books it traveled over. He then disappeared. I tested and found out his wire, rigged up a temporary table and furnished the report, stopping at the office until the arrival of the manager. The latter came at eight o'clock, and on entering the office was dumfounded. 'Who did this?' he inquired. 'Billy L.,' I replied, unwillingly. The manager walked the floor for a minute, then said, 'If Billy ever does this again I'll discharge him.'

"It was the habit of the night boys to go off on a *jamboree* quite frequently. Not being a drinking man, I was generally induced to act as treasurer and dole the money out in such quantities as to secure comparative sobriety at work time. A new man joined the force and gave up his money with the rest. When sober he was very mild-mannered, but on one of these excursions I didn't gauge his capacity for alcohol exactly right. He demanded more money, which I refused, whereupon he knocked the treasurer down, and was proceeding to break me all up when he was pulled away by the others, and given such a mauling that he was three weeks in the hospital."

To Edison's kindly sympathies was



"IF BILLY EVER DOES THIS AGAIN, I'LL DISCHARGE HIM." [SEE PAGE 107.]

largely due the chronic impecuniosity in which he was plunged. Having no dissipated tastes of his own to indulge in, and dwelling in a region remote from the exactions of fashion, his spare cash, outside of scientific claims, was always at the disposal of any brother in distress or disgrace. This fact was speedily ascertained by his associates and utilized in the most barefaced manner. The Louisville operators were experts in their line, but the demoralization produced by the war had resulted in a nomadic system which played havoc with morals and discipline. They were known as "tramp operators," and picked up a precarious living wandering from city to city, terminating each engagement, as a rule, by a gigantic spree. It was this class which principally sponged upon Edison. On one occasion our hero invested in fifty volumes of the North American Review at an auction, carried them home in triumph, and disposed them tastefully about the walls of his room, which at this time was affording refuge to half-a-dozen scientific arabs. These gentlemen, after watching the operations of their host, concluded that the new consignment would subserve their interests better by being transplanted to another sphere, and availed themselves of Edison's absence to purloin the whole set of ponderous volumes, carrying them to a pawnshop, where the equivalent they received formed the basis of copious potations. On another occasion Edison returned after a night of hard work at the unearthly hour of 3.30 A.M., to find his room reduced to the semblance of the ruins of Carthage, and two of his guests in bed with their boots on.

"I felt," remarks Mr. Edison, with humorous despair, "that this was running hospitality to the ground, so I pulled them out, and left them on the floor to cool off from their alcoholic trance."

Edison's nocturnal expeditions were the means of exciting suspicion amongst the guardians of public safety, and nearly resulted in serious consequences.

"I was once returning," he says, "from an auction, at 3.30 A.M., with a load of books on my shoulder, when a policeman halloed me to stop, following up his injunctions with a pistol-shot when I failed to comply. He had taken me for a thief, retreating from some burglarious enterprise, and his suspicion had been strengthened when I, being unable to hear, made no answer to his first challenge. My identity was known to him, however, and he released me instantly on a closer inspection."

It may not be generally known that Edison's deafness was contracted by the brutality of the Grand Trunk conductor who, in ejecting the lad from the car, boxed his ears with such violence as to injure indelibly the delicate auditory nerves and membranes. The disease has never yielded to surgical treatment, although the finest skill has been employed, but the great inventor accepts the infirmity with the sunny philosophy which is one of his distinguishing characteristics, and pursues his labors without a tinge of that self-pity which affords to lesser minds such depths of consolation.

Here Edison issued his first electrical treatise, and here was evolved the style of penmanship, a specimen of which is given. Legible and symmetrical as it is, he was able to produce it at the rate of forty-five words a minute, a speed commensurate with the extreme limit of a Morse operator's powers of transmission.

The old office was abandoned in course of time for a spacious building, richly furnished and supplied with excellent mechanical appliances. With the improved facilities of the company, however, came a stricter code of discipline, of which Edison was unfortunately the first victim. The instruments were now riveted firmly in place, and the operators were forbidden under severe penalties to remove them. A similar embargo was laid upon the chemicals, both of which wholesome regulations were disregarded. Each instrument was cautiously abstracted and utilized as a basis for experimenting, and the

chemicals shared the same fate. "I went one night," says Edison, "into the battery room to obtain some sulphuric acid for experimenting. The acid in the carboy tipped over, ate up the floor, and went through to the manager's room below, ate up *his* desk and all the carpet. The next morning I was summoned before the board and told that what they wanted was telegraph operators, not experimenters, so that I was at liberty to take my pay and leave."

From this home of outraged virtue, Edison betook himself to Cincinnati, thence to Port Huron, a period of about eighteen months, which brought him to the twenty-first year of his age. His work was of a character similar to that which, at Louisville, had been so ruthlessly sacrificed on the altar of experimental science, and the commonplace grind of his duties was again enlivened by stolen trips to the Mechanics' Library, together with the prosecution of pet inventive schemes. One of the latter was an ingenious device by which a single submarine cable could be utilized for two circuits, and by which a saving of $5000 was effected. This was adopted by the Grand Trunk Railway Company, who presented the young inventor with a free pass to Boston, where a position awaited him in the Franklin telegraphic office, secured by the friendly offices of his life-long friend, Mr. Milton Adams.

Edison was, as usual, in deep financial waters. His insatiable cravings for scientific appliances, together with a pressure of home claims and outside charities, left little or no surplus for the toilet, and the adornment of his person always took a subordinate place in his calculations.

"I had been four days and nights on the road," said Mr. Edison, "and, having had very little sleep, did not present a very fresh or stylish appearance, especially as compared to the operators of the East, who were far more dressy than their brethren of the West. The manager asked me when I was ready to go to work. 'Now,' I replied. I was then told to return at 5.50 P.M., and punctually at that hour I entered the main operating rooms, and was introduced to the night manager. My peculiar appearance caused much mirth, and, as I afterwards learnt, the night operators consulted together how they might 'put a job on the jay from the woolly West.' I was given a pen and assigned the New York No. 1 wire. After waiting upwards of one hour I was told to come over to a special table, and take a special report for the *Boston Herald*, the conspirators having arranged to have one of the fastest senders in New York to send the dispatch and 'salt' the new man. I sat down unsuspiciously at the table and the New York man started slowly. I had long since perfected myself in a simple and rapid style of handwriting, devoid of flourishes, and susceptible of being increased from forty-five to fifty-four words a minute by gradually reducing the size of the lettering. This was several words faster than any oper-

I have my own ideas, and I take my stand upon them, you know. A man who does that is always charged with eccentricity, inconsistency, and that kind of thing.

"Middlemarch."

EDISON METHOD OF KILLING COCKROACHES. [SEE PAGE 112.]

ator in the United States. Soon the New York operator increased his speed, to which I easily adapted my pace. This put my rival on his mettle, and he put on his best powers, which, however, were soon reached. At this point I happened to look up, and saw the operators all looking over my shoulder, with their faces shining with fun and excitement. I knew then that they were trying to put a job on me, but kept my own counsel and went on placidly with my work. The New York man then commenced to slur over his words, running them together, and sticking the signals; but I had been used to this style of telegraphy in taking report and was not in the least discomfited. Finally, when I thought the fun had gone far enough, and having about completed the special, I quietly opened the key and remarked, 'Say, young man, change off, and send with your other foot.' This broke the New York man all up, and he turned the job over to another man to finish."

This dazzling feat was the means of permanently securing the respect of Edison's associates, and "the jay from the woolly West" took his place at once and for ever as a prominent and esteemed member of the community. Here also the desolate and friendless boy was cheered by the intelligent sympathy of Mr. Adams and Mr. G. F. Millikin, the manager, the first men

possessed of sufficient intuition to gauge the splendid qualities underlying that uncouth exterior.

Vitalized by the sunny influences around him, sustained by a sense of recognized and inherent power, and, through a happy turn in home affairs, relieved from the cruel pressure of want, Edison's latent humor came into play, and found expression in many harmless pleasantries, notably the wholesale destruction of certain huge and aggressive cockroaches, which devastated the premises. Sanguinary hostilities had long been on foot between the operators and the insects, with decided advantage on the latter side. Once in a while some gifted human strategist would consign a battalion of the enemy to a watery grave, or, heading a frantic war-dance of his peers, reduce a couple of regiments to a mere spreading of animal matter; but these engagements were rarely crowned with success, and did not tend materially to depopulate the inimical forces. The feud was now a hereditary one, like the Punic wars of old; quickened with the gore of patriotic insects, and stimulated into abiding vigor by the successive odes of horned and antennaed bards. Marshaled by keen and doughty veterans, and hourly reinforced by new-born valor, the enemy was perceptibly increasing in numbers, strength and ferocity, whilst the courage and skill of the besieged were waning in equal ratio. No hiding-places, however cunningly constructed, could hold their foraging parties at bay; no shelf, hook or nail their scaling forces. Over books, papers, instruments, provisions and garments, lay the shining track of the foe, like the trail of the serpent on the emerald bowers of Eden. It was at this critical juncture that our youthful knight made his appearance. Single-handed and like "Ithuriel of the fiery spear," armed only with the luminous lance of electricity, he vaulted into the lists, war and conflagration in his path, and this was the manner of that memorable fray, told in the prosaic terms of the nineteenth century.

"Curiosity betrayed our Mother Eve," if we may credit an exalted, though ungallant source, and curiosity lured those invincible insects to their doom. Death in the thin masquerade of water-traps, bootheels and rough on roaches had long been sufficiently familiar to inspire contempt, but the king of terrors in Edisonian garb was an unknown factor in their calculations. Our ingenious trickster proceeded to secure certain alluring strips of shining tinfoil against the office walls, basted with such edibles as appeal most strongly to the gastronomic instincts of the cockroach, connected the strips with a powerful battery, and was rewarded by the spectacle of a steady rain of calcined insects pouring from the improvised crematory overhead.

(*To be continued.*)

INFLUENCE OF PATENTS ON AMERICAN INDUSTRIES.—I.

By Leon Mead.

IN the development of our national industries the United States Patent Office has been a greater factor than any other belonging to our public service. Its influence on the growth of the American Republic has been vast and incalculable. The interests, says a well informed writer in a recent magazine article, with which the Patent Office directly or indirectly deals affect at least nine-tenths of our people. It is a grand repository of the most ingenious devices as well as stupendous conceptions of the human mind.

A complete and comprehensive history of the Patent Office remains to be written. Whoever shall attempt the herculean task must necessarily devote to it many laborious years, and when at last he should write "Finis," he probably would be afflicted with misgivings that he had not exhausted the subject. If, therefore, we attempt a retrospective survey of the Patent Office we do so with a clear realization that in the space at our disposal we can only sketch at best the merest outline—a small silhouette against the broad horizon of its past.

The American patent system has been in practical operation a little more than a century, and in that time our country has exhibited the most remarkable evolution in commerce, agriculture and the mechanical arts of any known civilization. In the old colonial days, before the adoption of the Federal Constitution, inventors were granted exclusive privileges by some of the provincial governments, but the protection thus derived was more or less vague or valueless. The American Patent Office, the inspiration and child of Thomas Jefferson, was founded by an act of April 10, 1790. Some of the laws and practice of this new administrative department were borrowed or adopted from various Old World systems, notably from the English patent system, which came into existence in 1624; but certain it is many of the details observed in the direction of the office originated with Mr. Jefferson, who displayed great interest in it from the start. The first board of commissioners constituted by the law of 1790 comprised Mr. Jefferson, Secretary of State, Henry Knox, of Massachusetts, Secretary of War, and Emanuel Randolph, of Virginia, the Attorney-General, who were empowered "to grant patents for any such useful art, manufacture, engine, machine or device as they should deem sufficiently useful and important." They also were authorized to reject patents lacking in novelty or requisite utility and importance. That these three distiuguished officials treated every application with critical rigor is attested by the fact that during the first year only three patents were granted. During the next three years sixty-four patents were granted.

In 1793 an amendatory statute was enacted much against the wishes of Mr. Jefferson, who wisely maintained that the revision of the original act would lead to the promiscuous granting of patents and "the creation of monopolies." The law of 1793, however, did not materially differ in general construction from that of 1790, except that it refused patents to persons not citizens

of the United States, and that the power of revision and rejection was destroyed, and the duty of granting patents was vested alone in the Secretary of State. For an extension of a patent no provision was made at that time. While Mr. Jefferson believed in encouraging and fostering inventive genius, he held rigidly to the doctrine that a too liberal exercise of the tribunal's power in granting patent privileges would prove pernicious in its effects and detrimental to the interests of the country. The law of 1793 relating to aliens was so amended by an act passed April 17, 1800, as to give those who could prove a residence of two years in the United States citizen's rights—conditioned upon an affidavit filed with their application declaring their inclination and intention to become citizens of this country.

One of the most memorable patents under the act of 1793 was granted to Eli Whitney, the inventor of the cotton gin. The incident which suggested to him this invention, to which nearly every Southern State owed its acquirement of wealth and power, may be familiar to many readers of this article, but it is worth repeating. Eli Whitney, the son of sturdy New England parents, early manifested a love of mechanics and some of his youthful contrivances were the wonder of the neighborhood of Westborough, Mass., where he lived. He disliked farm drudgery, and, though opposed in the purpose by his father, he determined to go to college. By teaching school and peddling articles of his own handiwork about the countryside, he managed to save enough money to enter Yale, from which he was graduated at the age of twenty-seven. He was still passionately fond of mechanics, but poverty precluded the idea of his following his natural bent and adopting the profession of a teacher seemed his only recourse. Accepting an offer to act as a tutor in the family of a gentleman living in Georgia, young Whitney started for the sunny South. During the journey thither he made the acquaintance of the widow of General Nathaniel Green, one of the famous heroes of the Revolution. The lady became interested in him and invited him to pay her a visit, while *en route*, at her home near Savannah. It was fortunate for him that he accepted the invitation, for soon afterward he learned that another tutor had been engaged by the Georgia gentleman.

Whitney demonstrated his aptitude for mechanics by making for Mrs. Green a much better tambour for holding her delicate embroidery work than any she had ever possessed. In other minor ways he inspired her with a wondering confidence in his mechanical genius. One day some old army friends of her husband, who were her guests at Mulberry Grove, discussed the topic of cotton culture in the South. They all agreed that the great obstacle in the way of an enormous and most profitable cotton production was the great labor necessary to separate the seeds from the lint. The work of a good cotton picker amounted to only five pounds a day, requiring at this rate ninety days to separate the yield of one acre of land. One of the officers remarked that if anyone could discover a method by which the cotton could be more easily cleaned the output of cotton would be prodigiously increased and become the most lucrative industry in that part of the world. Whereupon Mrs. Green, who had been an intent listener, exclaimed: "Gentlemen, tell this to my young friend, Mr. Whitney. I verily believe he can make anything."

Though wholly unfamiliar with cotton and its mode of growth Whitney, on hearing what the officers had to say, resolved to devote his attention to the problem suggested and to solve it. And solve it he did. Within the next two or three months he constructed a practical machine that could easily separate seventy pounds of fiber a day. He forwarded a model of his cotton gin to Thomas Jefferson, who personally interested himself in the application and secured a patent for the young inventor, between whom and Mr. Jefferson a warm friendship existed for a number of years. But Whitney was not destined to enjoy the pecuniary reward of

his invention which made possible the significant fact that in 1889-90 eighty-five per cent. of the cotton crop of the entire world was produced by the United States, though some deference, at the same time, should be paid to the magnificent soil of the Southern States—a soil whose adaptability for the raising of cotton has no approachable equal on this terrestrial footstool of the Almighty. Before Whitney actually secured the patent the virtues and value of his invention had been noised far and wide. One night his cotton gin was stolen from the outhouse in which it had been kept and in a short time duplicates of it were set into operation in every cotton-bearing section of the South. Such was Southern chivalry in those days. Congress gave him no redress or compensation, all his petitions to that end being in vain. But, in the impressive language of George Makepeace Towle, Eli Whitney "was a patient and heroic spirit. He bore the injustice of men and the ingratitude of his country with cheerful serenity and died assured at least of a deathless fame, with his name enrolled high up on the list of the world's greatest inventors."

In speaking of the immense utility of the cotton gin a distinguished Southerner has said: "The whole interior of our States was languishing; our inhabitants were emigrating for want of some object to engage their attention and employ their industry, when the invention of this machine at once opened views to them which set the whole country in active motion. From childhood to age it has presented to us a lucrative employment. Individuals who were depressed with poverty and sunken in idleness suddenly found occupation for their hands and have risen to wealth and prosperity."

Another case analogous to Whitney's in point of the brutal disregard of personal rights on the part of men in general was that of Robert Fulton, the inventor of the first steamboat. He, too, was a not willing martyr of his own genius. It is not claimed for Fulton, by even his most enthusiastic biographer, that he was the first man to perceive the possibility of applying steam to navigation. That desideratum existed among advanced nations long before Fulton discovered the principle and established the practicability of steam as a motor power for vessels. His own countrymen, John Fitch and James Rumsey, had tried to perfect the steamboat, as had the Marquis de Jouffroy in France and Miller and Symington in Scotland. As a matter of fact the last named—James Symington—launched a boat one fog-laden morning in the autumn of 1788 on the Lake of Dalwinston which sped away *under steam* at five miles an hour. What made the occasion more memorable was the presence on board this craft of Robert Burns, afterward to shine, by no reflected rays, as a great, distinct and universal poet. A few other men of great subsequent note were aboard, including Henry Brougham, who became Lord High Chancellor of England. But Symington's steamboat lacked in certain essentials and, while his invention impressed the public of that day, it was not deemed sufficiently practical for general adoption. The paddle wheel is said to have been used among the ancient Egyptians as a means of propelling boats on the river Nile, and seven centuries ago its use was commended by European writers and scientists. Even the non-progressive Chinese are credited with understanding something about the paddle wheel as early as the seventh century. Robert Fulton belonged to a poorly circumstanced Pennsylvania family. He somehow managed to get to Europe, where he began the study of painting under his fellow countryman, Benj. West, at that time the great court painter. Fulton, however, soon abandoned his studies in that line and turned his attention to mechanics, of which he had always been especially fond. He received splendid preliminary training for the work upon which he later bent all his energies, with the courage born of an ambition to achieve a place of honor in the world. In the construction of the Bridgewater canal in England he

gave no meagre assistance by inventing inclined planes for locks for the passage of canal-boats. New methods of making ropes, and a mill for the sawing of marble were among his other inventions. The English public at that time were excited over the experiments being made to apply steam to navigation and Fulton caught the fever of the hour. "As he thought with glowing pride of the fifty thousand miles of navigable rivers which flowed through our Western States, inviting to them population, capital, and business energy, he saw that the steamboat, if it could be perfected, would be the means of developing those vast, rich and fertile Western lands." For fourteen years he worked and experimented. He made considerable headway toward the attainment of his purpose, but there were some obstacles still to surmount. Other great inventors of the day, such as Watt and Cartwright, gave him valuable advice, and he had the good fortune to number among his patrons the American minister to France, Edward Livingston, at whose residence in Paris he lived for a number of years—a welcome inmate. Meanwhile, his fame was growing. The great Napoleon, on being informed of the young toiler's project declared that "it was capable of changing the face of the entire world." Finally, provided with ample funds advanced him by his public-spirited friend, Mr. Livingston, Fulton came to New York and built the famous "Clermont." He was morally certain that his invention would prove successful. The description of the launching of the first steamboat cannot be better stated than in the words of an eminent historian: "It was on a morning in August, 1807, that the 'Clermont,' all completed, with her engines duly equipped and fixed—a novel sight for the lookers-on to see—lay moored at her dock in the North River. The momentous day for her first trip had arrived. A crowd assembled at the dock to see her start. Fulton, with beating heart, stood on the little dock, surrounded by a group of curious and anxious friends. The word was given, the engine was started, and the 'Clermont' pushed out upon the stream. Then after going a little way, the boat suddenly stopped. It was a moment of harrowing suspense to the brave inventor. A slight hitch in the machinery was speedily discovered. It was quickly set right and the 'Clermont' amid murmurs of wonder and delight, resumed her voyage. As she steamed up the Hudson, by the Palisades, between the lofty banks of Yonkers and Tarrytown, past the wooded heights of West Point, the country people from miles around gathered on the shore on either side to witness her progress. They were bewildered and terrified. The 'Clermont' indeed seemed to their eyes a monster moving on the water, defying the winds and tide, and breathing flames and smoke! When the crews of the river boats heard the rumble of her machinery and the splashing of her paddles, and saw the steam and sparks bursting from her valves and funnel, they flew below-deck in their fright; or, prostrating themselves on deck, prayed to be protected from the horrible creature which was marching on the tides and lighting its path by the fires which it vomited."

Indeed, Fulton's steamboat must have been quite as much of an awesome mystery to the Yankee eyes that beheld it, as had been, two centuries before, the sight of Hendrik Hudson's cumbersome craft to the trembling North American savages that swarmed the densely wooded shores of the noble river. Without mishap, "the 'Clermont' reached Albany, and Fulton and his friends stepped exultantly ashore. His great end, after so many years of difficulty, trial and perseverance, was at last accomplished. Steam navigation had become a fact. The great test had been successful; and thenceforth all the waters of the earth were to swarm with steam vessels, of which the little 'Clermont' was the parent and the pioneer."

Other steamboats and a steam frigate were subsequently built by Fulton, but like Whitney, and scores of great in-

ventors before and since his time, he was prevented from reaping the fruits of his weary labors. Dishonest men, by those wiles so well known among heartless scoundrels, robbed him right and left; his patents were disputed and he was drawn into many tedious and unprofitable litigations. The overdraft upon his naturally limited vigor, induced by many exasperations and misfortunes, caused his death. He passed away in 1815—a heartbroken man; but throughout the land there was general mourning for the proud, persistent yet sensitive spirit, whose earthly frame had been brought to so untimely a grave.

For twelve years after its foundation, one clerk, nominally in the State Department, performed the work of the Patent Office, and his duties therewith were by no means onerous. In 1802 the clerk was superseded by Doctor Thornton, whom Mr. Jefferson appointed to take charge of the office, and who thereafter during his incumbency, which lasted for twenty-six years, was styled its "Superintendent." Doctor Thornton, it appears, was something of a savant, but autocratic, dictatorial, and not over scrupulous. Self-interest led him to commit indiscretions, and there was a general lack of system in his management of the affairs entrusted to him. Several important inventions came to light during the Doctor's regime, and it is alleged that he figured as a co-patentee in no small number of them. These inventions mainly embraced agricultural implements—crude enough, too, they were in comparison with those of to-day; machinery for navigation, and guns and impossible weapons galore, for the war of 1812 seemed to force the Yankee brain into all kinds of spasms of ingenious, if not always valuable productions. Doctor Thornton was in charge of the Patent Office in those martial days. A story is told of him to this effect: When the British captured the city of Washington and destroyed the Capitol building, a loaded cannon was trained upon the Patent Office for the purpose of destroying it, and he is said to have put himself before the gun, and in a frenzy of excitement exclaimed: "Are you Englishmen, or only Goths and Vandals? This is the Patent Office, a depository of the ingenuity and invention of the American nation, in which the whole civilized world is interested. Would you destroy it? If so, fire away, and let the charge pass through my body." The effect is said to have been magical upon the soldiers, and to have saved the Patent Office from destruction.*

In the same year (1812) the patent office was removed to a building purchased and repaired for the accommodation of the General Post Office and of the "office of the keeper of the patents," in accordance with an act passed two years before by Congress, which appropriated in all about $35,000 for the purpose. That building stood on the site of the present magnificent edifice occupied by the Post Office Department. For about two years—from 1828 to 1830—a Mr. Jones acted as "superintendent" of the Patent Office and then another doctor, J. D. Craig, succeeded to the position which he held until 1836. Dr. Craig was taken to account for certain irregularities in about the middle of "his reign," and the Secretary of State, after a close investigation, resulting, by the way, in some very queer revelations, severely reprimanded Dr. Craig, and for the future government of the office laid down some plain business rules which, it is said, were strictly followed.

In 1836 the Patent Office was reorganized. Up to that date 11,348 patents had been granted, many of which were neither novel nor useful and, therefore, like "Dead Sea fruit." It became evident that abuses had grown out of the promiscuous granting of patents, made possible by the defective law of 1793. Senator Ruggles, of Maine, proposed an investigation and a committee of five was appointed to that end. The committee submitted to the Senate an extensive report of the evils, frauds, pirated inventions, etc., which they discovered, and on the

* From an old government report.

same occasion introduced a bill for the reorganization of the Patent Office, which became a law on July 4, 1836. The old system was thoroughly revolutionized by this statute, which made the Patent Office a bureau of the Department of State, with a so-called "Commissioner of Patents," to be appointed by the President, with the consent of the Senate, as its chief officer. A chief clerk, who was to act as custodian of the seal, records and models of the office and to represent the Commissioner during the latter's absence, an examining clerk, two subordinate clerks, a machinist and a messenger were also provided for. Substantially the same regulations respecting specifications, drawings and models, etc., were retained as had been devised in the original act of 1790. One section of the new law, however, was an innovation. It provided for the establishment of a system of examination under the direction of the Commissioner "of the alleged new invention or discovery," in order to determine the validity and good faith of the application. The statute of 1836 embodied other important features which are retained to-day. It provided for the arrangement and classification of the models in the office, created the caveat system "by which an inventor could, by paying $20, file in the Patent Office a caveat setting forth the design and purpose of his invention, its principal and distinguishing characteristics and praying for protection of his right until he could mature his invention." Under the provisions of the statute of 1836 an appropriation of $1500 was made for the creation of what has since become an enormous and invaluable scientific library. The working force of the Patent Office after its reorganization consisted of eight people, including the Commissioner, Henry L. Ellsworth, of Connecticut, father-in-law of the late Roswell Smith, who, at the time of his death, was president of the Century Company. In a loft of the old Post Office building the Commissioner fitted up a model room in which he evinced remarkable interest. The system of intelligent examination thus established bore good results; for it interdicted the issuance of patents that were wanting in originality and real merit. Discrimination was made in favor of the American patentee, but the two years' residence required of aliens under the former act was reduced to one year. By some strange inconsistency a subject of Great Britain was obliged to pay $500 upon making his application, and for all other foreign applicants the fee was $300. This discrimination was abolished by an act of March 2, 1861, and on the same date the fee for filing a caveat was reduced to $10, as at present. Under the old system, during the first half of 1836, 625 patents were granted, while in the last half of that year, under the new law, there were only ninety-seven.

The Post Office building was burned December 15, 1836. The only thing rescued from the flames belonging to the Patent Office was one unimportant book. Many of the archives of the General Post Office Department were saved. The fire is supposed to have originated in a pile of old rubbish in a cellar directly under the city Post Office. About 7000 models were destroyed. They included models of the inventions of Thorpe, Danforth, Browne and others for facilitating the manufacture of cotton and woolen fabrics; models of the improved machines patented to Parsons, Dewey, Stowell and others for shearing and napping cloth; models of the purely American machines for manufacturing cut and wrought nails; numerous models of improvements in saw mills, grist mills and water wheels; a great number of models illustrating the application of steam power to all kinds of machinery; nearly 1500 models of improved implements of husbandry; nearly 2000 models of inventions and improvements in factory machinery and in the various manufactures, and as many more having for their object the advancement of the common mechanical trades. At that time it was thought that certain drawings or models of new inventions were of value, even if the machinery which

they represented did not prove their usefulness in practical operation. Senator Ruggles, in a report submitted to the Senate after the fire of 1836, had this to say on that point: "Mechanical science, like all others, is matured and perfected by degrees, and by calling to its aid the investigations and ingenuity of various minds. Most inventions are but the foundation of progressive improvements. It is necessary to know what has been done in order to know what remains to be accomplished. Every age avails itself of the experience and discoveries of that which has preceded it. Were it otherwise knowledge would be stationary and every generation, instead of being wiser than others gone by, would be employed in learning over again what had been acquired before." In his opinion even imperfect inventions might furnish hints for the full accomplishment of the design, and contrivances of apparently but little value might serve as beacons to enable others—the model rooms of the Patent Office being visited by men of genius and science from all sections of the country and from Europe—to avoid fruitless labor and expense. He moreover contended that models were indispensable for the use of patent officials and he strongly recommended the restoration of lost models, at the same time admitting that it was not necessary to replace them all. Provisions were made for obtaining duplicates of the most valuable and interesting models destroyed by the fire of 1836, $100,000 being appropriated for that purpose. Several thousand of the models and drawings were replaced, though a few could not be duplicated at any cost, as for instance, the beautifully executed drawings by Robert Fulton of his steamer making its first trip up the Hudson. In 1849, after twelve years of effort to rehabilitate the model rooms and an expenditure of nearly $90,000 out of the appropriation, the work of restoration was discontinued.

About five months previous to the destruction of the old Post Office an act was passed providing that "the President of the United States cause to be erected on some appropriate site, a fire-proof building, with suitable accommodations for the Patent Office," and out of the patent fund $108,000 were appropriated for that purpose. Work was begun on the foundations in the fall of 1836. The main building, of Virginia sandstone, faced with split granite, laid in regular courses, with dressed joints, was finished and occupied by the Patent Office in the early part of 1840. Its cost was $422,011.65. Its magnificent proportions are exactly those of the Parthenon at Athens. The Commissioner thought the new building was sufficiently capacious for the needs of the Patent Office for many years, but in 1844 he stated in his annual report that the models of patented inventions were crowding so much as to prevent classification and that there seemed to be no alternative but to extend the building. It was not until March 3, 1849, however, that Congress appropriated $50,000 out of the patent fund to begin the east wing. In 1852, at a cost of $600,000—$250,000 of which were taken from the earnings of the Patent Office, it was completed and occupied. The same act which appropriated $50,000 for the commencement of the east wing, created the Department of the Interior, to which was transferred, as its chief bureau, the Patent Office, from the Department of State. At this period the inventive impulse of our countrymen was very marked. The east wing was rapidly filled up and there was a clamor for more space; so that on August 31, 1852, Congress passed an act authorizing the erection of the west wing—to correspond with the east wing—and appropriated $150,000 to begin it. At a cost of $750,000 the west wing was completed and occupied in 1856. The north wing, completing the grand structure, was begun in 1856, and entirely finished in 1867, costing $575,000. Up to 1871 nearly $3,000,000 had been expended upon its construction, repair, and furniture.

Shortly before noon on September 24, 1877, the roof of the west wing of the Patent Office was discovered to be

on fire. An alarm was immediately sounded and the fire engines responded promptly, but twenty minutes elapsed before the first stream of water was playing on the fierce flames. Carrying the hose through long corridors and up two stairways, as the firemen were obliged to do, caused delay; and the pressure of the hydrants proved of no avail, for the fire was some eighty feet above the street and twenty feet above the highest rise of Potomac water. A large and excited throng gathered about the building, but no one for a moment believed that such a massive pile of granite could be damaged by fire. Under the glass roof, covering the south end of the west wing, was a conservatory, where many plants were housed during the winter-time. A little to the north of the conservatory was a room containing about 12,000 rejected models. The staging and shelving of this loft were of inflammable material, a great many thousand feet of white pine lumber having been used in the construction of the roof. On the floor below was situated the model room, taking up the whole of the third story. This gallery, comprising four grand halls, each communicating with the other, was visited by thousands of people every day. It contained about 200,000 models of American invention, besides innumerable curiosities and mementoes of great historic interest. Some of the national relics that were on exhibition there, such as the printing press first used by Benjamin Franklin, several of Washington's personal effects, etc., now to be seen in the National Museum, were saved, but other souvenirs of perhaps equal value and interest were destroyed. Inside the building there were practically no safeguards against a conflagration. The actual cause of the fire still remains a matter of doubt. Several theories of its origin were suggested during the subsequent investigation. It was conjectured that a wooden grating on the roof was ignited by a spark from the chimney, and, burning through the thin copper sheathing, thus communicated fire to the wooden portion of the ceiling underneath. Alexandria sent her one little engine speedily, and Baltimore sent four more as fast as they could get there by rail. Officials and clerks of departments, and many citizens did heroic service. At half-past twelve a stiff breeze blew up and now the crisis of the raging acres of fire had come. But the firemen did not despair. Attaches of the building ran to and fro, endeavoring to save the contents of their offices. They succeeded in safely removing 777 priceless folios, containing 211,243 original drawings, besides other valuable records and office furniture from exposed portions of the building; but little could be done in the halls of the west and north wings to save the models, which were nearly all destroyed. On the following morning a crowd of relic-hunters gathered, impatient for the ruins to sufficiently cool so that they could dig out some memento of the great fire to carry home. Several mud-stained and bedraggled engines were still panting, for beneath the mass of rubbish and twisted iron the fire was smoldering. In the uninjured portions of the building the rescued articles were piled in motley confusion. The west and north wings, and nearly all they contained were completely destroyed. In these two halls were 87,000 models—among them thousands of "pending" and "issue" cases. The 7000 models which were the pride of our government in 1836 had expanded to about 200,000 in 1877. Classified in chronological order, this stupendous collection illustrated to the eye of the visitor almost at a glance the growth of each art. Nothing in the world ever equaled it. Students of mechanics and of the industrial arts from all over the globe found there untold volumes of enlightenment. Attended as it has been with two fire casualties and, at times, with flagrant mismanagement, the Patent Office still remains one of the foremost institutions in our national autonomy. Like the ghost of Banquo, it will not "down."

The fire of 1877, though twenty times the amount of property was destroyed, was not nearly so disastrous as that of

1836. The models, written and illustrated records of the office were all consumed in 1836, while comparatively little of original value was destroyed by the fire of 1877, except the models, consisting of the three classes—the patented, the pending cases, and the rejected models. The extent of their loss could not be correctly estimated. In the pending cases the pecuniary losses fell upon the inventors. Save in a few isolated cases, the losses were not absolutely irreparable. The model collection undisturbed by the fire of 1877, has since been fairly well arranged, though the work of thorough classification has been arrested, owing to an inadequate clerical force, and also on account of insufficient storage space, notwithstanding the fact that the west and north wings of the Patent Office were promptly rebuilt upon their destruction.

During the first fifty years' existence of the Office 372,215 patents were granted. Between 1840 and January 1, 1892, 787,500 applications were filed.

PISTON ROD PACKINGS.

By B. W. Goodsell.

PROBABLY no specialties in engine supplies have received less attention at the hands of mechanical writers, more condemnation at the hands of engineers, or a more energetic effort at the hands of the manufacturers than have piston rod packings. Hence to assume the responsibility of incurring the criticism that may follow an article on this subject requires the courage to "throw down the gauntlet." But as the offering of opinions opens the way to argument, a new interest may be awakened and some benefit result to mankind generally, and possibly to those most interested in particular. Beginning with the application of steam into the first steam cylinder came also the necessity of the first stuffing-box packing, of which we have any record. With this necessity came also the birth and place for an article heretofore unasked and unknown. The imprisoned power required confinement, and the piston-rod freedom of action. Upon the accomplishment of this result hinged the success or failure of the first steam engine. Through what evolutions of development it passed will be best understood when we consider the inventions now upon the market. Few if any of the specialties used in modern steam engineering have shown a greater diversity of ideas, of materials employed, or their arrangement. Yet all have aimed to reach the same result. The entire list of vegetable and mineral fibres has been brought into use and experimented with, as have also the various anti-friction metals. For many years the "hank" of hemp or flax was the chief dependence of the engineman. Down through the years of experiment and consequent universal adoption of steam power came the increased demand for rod packings, and with it the opportunity of the inventor to construct and supply this want. The dawn of this new age brought with it a multiplicity of ideas more or less crude, but nevertheless useful. The laborious process of the plaitings of fibres by hand work gave forth a new result so satisfactory that nearly superseded all other materials, by its increased durability and protection of the strands. This paved the way for the construction of machinery which accomplishes the same result and which is now kept occupied unceasingly in various manufacturing plants. With the steady increase of steam power and the demand created by it, this industry has been fostered until it has grown to a business of no small importance. Millions of dollars are annually paid by our home manufacturers, railroads and

marine trade for packings, and thousands of operatives are employed in the manufacture.

With the gradual increase of steam pressure and the correspondingly high speed of piston rods, still further improvements became necessary and with them the natural anxiety to excel in the production of acceptable specialties. These demands were answered by the various manufacturers, and for the convenience of the user the application of various lubricating agencies such as tallow-greases, soapstone and graphite were embodied in the fibre and were always and now are a source of increased profit to the maker. When the vulcanization of rubber became known it was here appreciated and gradually began to be utilized in various ways to overcome the ever present objections of rigid bearing consequent upon the tendency of fibre to carbonize and become rigid in steam, and to further aid in adjustment in service. With this blessing of increased elasticity and the consequent increase in the *durability of materials* so cushioned, the variety also kept pace with the unlimited desire to compare the merits and results of each new offering.

Following in the footsteps of the earlier fibrous appliances came the metallic packings in great variety, and the gradual increase in steam pressure was again met by the many acceptable styles now offered. Their general application on rods has been hindered by the frequent non-condition of the average engine and the rapid destruction of such bearings where the alignment of rods has been imperfect. Simplicity of construction and ease of adjustment are essential requirements which should not be overlooked. Each new idea, however imperfect, will have served its purpose if only to show the necessity of overcoming a weak point. The modern engineer will not be satisfied with the conditions of the past, and the ever varying conditions under which packings are used as well as the unequal conditions of machinery upon which they will be tested, renders it impossible to obtain a uniform result that will be accepted alike by all.

Could the designers of engines be induced to provide stuffing-boxes of ample size and depth in order to give each class of packings an equal advantage, much trouble would be avoided. As it is, however, the selection of the most suitable packing really must be decided by the type and particular make of engine on which it is to be employed.

The great disadvantage reputable manufacturers as well as engineers have to contend with is the cheap product, which may look nice but having very little wearing qualities.

The manufacturer, however, who makes the greatest effort to elevate the standard of general excellence will be repaid with an increasing business, while the substitution of inferior materials will only be continued by those who seek the cheapest markets, and the writer will predict that as the electric light has so gloriously supplanted the "tallow dip" so will the honest and intelligent improvements in this line replace the impositions that may be heralded upon the market. The time is at hand when the appreciation of durable goods will be made known and all future requirements promptly met.

Then this line of supplies will occupy the same relative position to old ideas as does the modern Corliss engine to the first application of steam as a motive power. The successful designers and makers are men of energy, most of whom are working on advanced ideas. Their products are in the hands of the modern engineer whose opportunities for interchange of opinion and practical experience are greater than at any previous time. Meritorious goods soon become known through their councils, to all whose mission it is to use them. And as bad news always travel faster than good reports so approaches the day when trashy products in packings will receive their sentence at the hands of an intelligent jury.

A PECULIAR EXPLOSION OF A BOILER.*

By Fred. H. Daniels, Mem. Am. Soc. Mech. Eng.

ENGINEERS in these days of high-pressure steam find in the construction of boilers a study of great interest. Responsible makers are alive to the question and use all possible means to insure the strength and safety of their product, in order to prevent more or less disastrous failures. Accidents will, however, occur, and when they happen engineers are always ready to study cause and effect, in order to draw some conclusions which in the future may be of great value. A report upon a peculiar rupture which took place in one boiler of the steam plant of the Washburn & Moen Manufacturing Company, Worcester, Mass., may therefore be of interest.

Six years ago they equipped a portion of their plant with a battery of six horizontal tubular boilers, from plans furnished by H. S. Robinson & Co. The boilers were five feet in diameter, with tubes nineteen feet eight inches long, and were designed to carry a working pressure of 125 pounds to the square inch. The advantages of subjecting materials for boilers to a careful test by the consumer before accepting them were brought to our attention by Mr. H. S. Robinson, senior member of the firm mentioned, and we decided to have all the materials for our boilers, especially the shell plates, tested in a very exhaustive way at the Watertown Arsenal before permitting any of the material to be used. One plate out of the entire lot was condemned. These boilers have been in successful operation for nearly six years and are still in use. They are inspected every week. The water is run out, the man-holes removed and the interior as well as the exterior of the boilers carefully examined. As the water in the streams in the vicinity of Worcester is very pure, coming as it does from the granite hills, scale is never found in the boilers, but in the spring and fall, during high water, it is not uncommon to find a small deposit of debris, which is carefully washed out.

With all this care the accident was a real surprise. When it happened, the plant was running as usual, but the boilers were somewhat forced, although not to any extreme limit. Without any warning whatever, and with very little noise, the firing doors of the furnace were burst open, coal, ashes and water thrown out and the boiler house in an instant filled with steam.

As soon as an examination could be made it was found that one of the plates in the third row, just over the most intense heat, had bagged and ruptured, leaving an orifice about one inch in diameter, thinning the metal around the orifice to a knife edge. The remainder of the shell was not damaged, because the boiler quickly emptied itself of water and steam, which extinguished the fire and cooled the brickwork. The accompanying drawings (Figs. 34 and 35) illustrate the exact location of the rupture, also the arrangement and details of the boiler and setting. A careful inspection failed to discover scale or debris of any kind inside the boiler. The other five boilers of the battery were also examined at the same time, and we found two of them with their lower sheets slightly wavy, but nothing approaching a bag. The ruptured portion was cut out and a patch supplied in its place. The boiler has been in constant use since, without any sign of failure.

*Paper read before American Society of Mechanical Engineers.

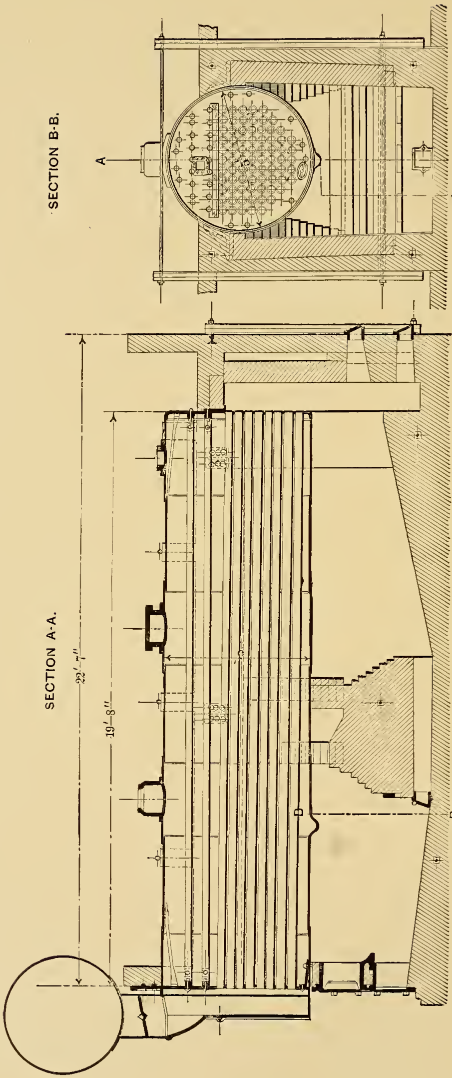
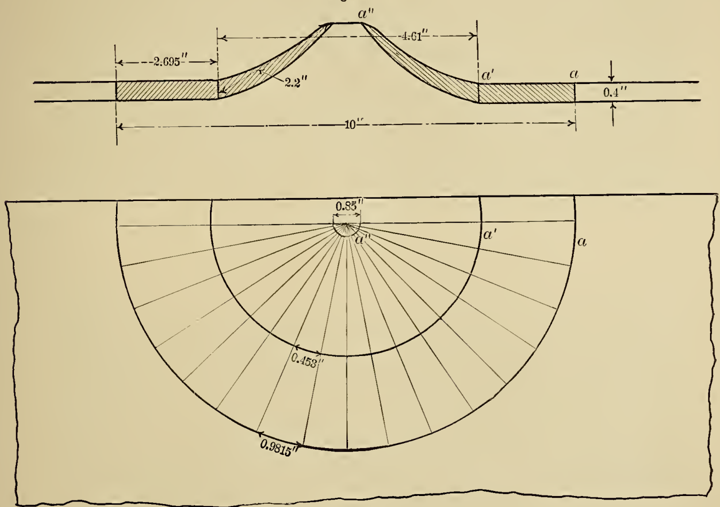


FIG. 34. DETAILS OF BOILER WHICH EXPLODED AT THE WORKS OF THE WASHBURN & MOEN MFG. CO., WORCESTER, MASS. FIG. 35.

Upon examination of the cut out piece, of which illustrations are shown, we found a very thin black scale around the rupture, and nearest the orifice it looked as if the plate had been highly heated, so highly, in fact, as to permit the cutting away of the hot metal. We carefully calculated the cubical contents of the plate (see Fig. 36) and found that there were 1.41 cubic inches less material in the half ten-inch circle, after rupture, than there was in the plate before. These in perfect condition, for the boilers were carefully inspected only four days previous to the accident and everything was found in good order. Two or three times during the past twenty years we have had boilers bag, but never before had one rupture.

All of the shell plates in this battery of boilers were stamped with numbers, and the original report on the tensile strength tests preserved. By referring to these records we found that the plate which was ruptured had on one

Fig. 36.



SECTION AT POINT OF RUPTURE.

figures, together with a careful examination of the plate, seem to indicate that for a few moments before the rupture the plate was subjected to a very high, possibly to a white, heat, and when the metal became sufficiently plastic and was in a proper condition for such a result, it simply flowed out, as shown in Figs. 37, 38, 39 and 40. It seems reasonable to suppose that this plate had been overheated for a very few minutes only and that previous to the time of rupture it had been end a tensile strength of 68,050 pounds and on the other end 65,650 pounds per square inch. It also stood well the "burr test" for annealing and water chilling. By way of comparison two test pieces were planed from the ruptured plate. (See Figs. 41 and 42.) The test piece which was farthest from the bulge held 60,486 pounds to the square inch and had a reduction of area of forty-one per cent. The test piece close beside the rupture held 61,666 pounds to the square inch and

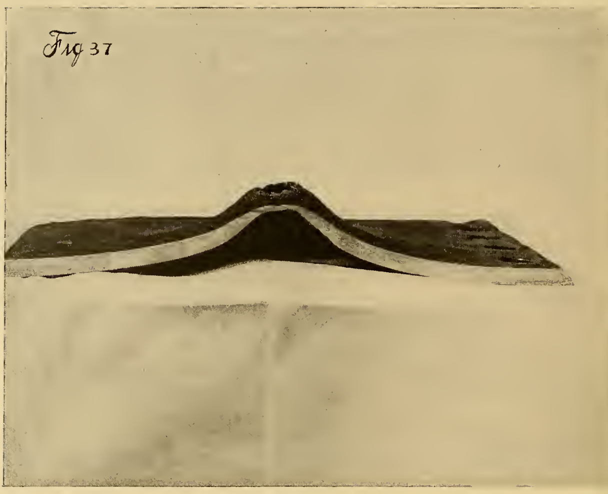


FIG. 37.

FIG. 38.

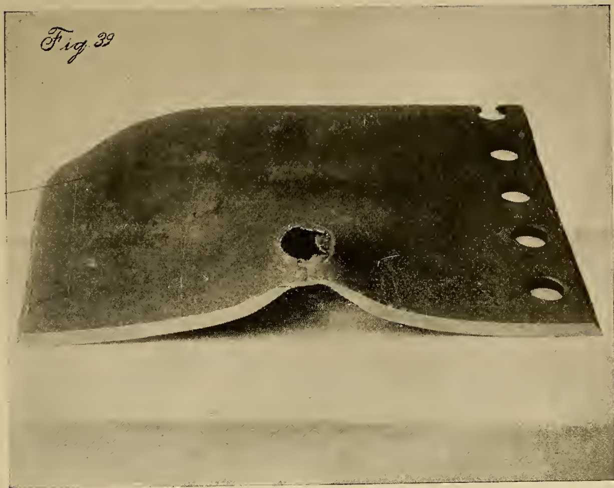


FIG. 39.

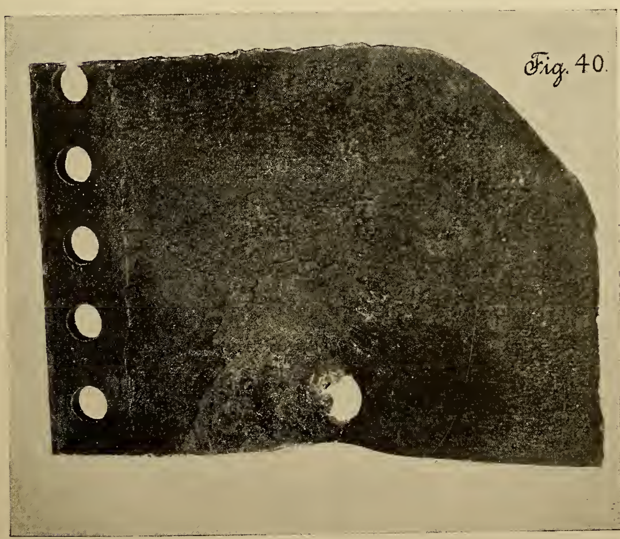
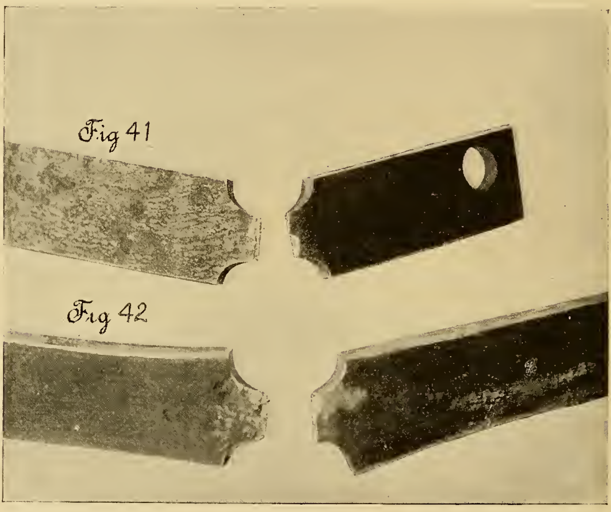


FIG. 40.

had a reduction ot area of over thirty-two per cent. It will be observed that the tensile strength is considerably less in the ruptured plate than in the original tests of the plate. This may be accounted for, however, by reason of the test piece having a twist in it, occasioned by the bulge in the plate, and having been put into the testing machine without straightening. "Burr tests" were also made. One of them, heated high and allowed to cool in the air, was hammered together as shown; the other, heated to redness and plunged in cold water and hammered as shown, without failure. The analysis of the ruptured plate is as follows:

Phosphorus	.063 per cent.
Sulphur	.022 per cent.
Silicon	.024 per cent.
Manganese	.261 per cent.
Carbon	10 per cent.

It has been suggested that this thin scale covered the entire surface over the fracture before the rupture and was caused by oil which had become burned on to the plate; but as the feed water for this plant was supplied from a closed heater it is difficult to see how oil could have found its way into the boiler. We have been informed by the builder that he was called a short time ago to examine a boiler of the same construction as the one referred to in this article. It had been overheated directly over the fire box, making the shell plates wavy. After carefully drawing the water from the boiler nothing could be discovered on the plate excepting a whitish powder. There was neither scale nor mud.



FIGS. 41 AND 42.

The conclusions the writer arrives at are, that the importance of mechanical, physical and chemical tests cannot be overrated. While the plate makers invariably subject their plates to tests and stamp them accordingly, at the same time a confirmation of quality by the consumer is desirable, for we have seen that in the tests at Watertown one plate was condemned. If the ruptured plate had been of improper material or had contained sufficient carbon to harden when the water came in contact

with the overheated plate a crack might have developed, resulting in a serious explosion, possibly destroying the entire plant and causing a loss of life.

In closing the writer desires to commend the very perfect system of checking the tests of plates used in the work produced by H. S. Robinson & Co., who built these boilers for the Washburn & Moen Company. During the nineteen years they had this system in use all the plates of the boilers produced by them have been retested and a complete record preserved of the tensile strength and the "burr test," at the same time recording the location of each plate in the boiler by properly stamping them. Such a system is of great value both to the maker as well as to the consumer, for any defects can then be traced and fully investigated.

LEADING AMERICAN ENGINEERS III.—ECKLEY B. COXE.

By William Kent, M. E.

THE newly-elected president of the American Society of Mechanical Engineers, Eckley Brinton Coxe, has been for many years one of the leading spirits in the engineering profession. In April, 1871, his name was the first signature to a circular issued by a committee consisting of R. P. Rothwell, Martin Coryell, and himself, calling a meeting of mining engineers, to be held at Wilkesbarre in May, to organize the American Institute of Mining Engineers. At this first meeting of the Institute he was elected one of its vice-presidents and in 1878 and again in 1879 he was elected president. Being a frequent contributor to the "Transactions of the Mining Engineers," and a constant attendant at its meetings, and being head of the well-known firm of Coxe Bros. & Co., the largest private corporation producing anthracite coal, his name and face are more familiar to the mining than to the mechanical branch of the profession, but since his work has been pre-eminently in the mechanical line, as in the invention and construction of machinery for mining, conveying, and separating of coal, and since the mechanical branch is indebted to him for the translating and editing of Part I. of Weisbach's Mechanics, the American Society of Mechanical Engineers has as much right to claim him and to elect him its president as had the older society.

Mr. Coxe comes from a family well known in the history of Pennsylvania. It is recorded in Watson's "Annals of Philadelphia" that one of his ancestors, Colonel Daniel Coxe, who came to America in 1702, made an elopement in his youth with an heiress, Sarah Eckley, a Friend, that they were married in the woods in Jersey, by fire-light, by the chaplain of Lord Cornbury, the then Governor of New Jersey.

Colonel Coxe published in 1727 a description of the English province of Carolina, of which his father was proprietor under conveyance from Sir Robert Heath, attorney-general for King Charles I., to whom the province had been granted by royal charter in 1629. A grandson of Daniel Coxe was the well-known Tench Coxe, of Philadelphia, statesman, financier, and author, who was commissioner of internal revenue during Washington's administration. Tench Coxe died in 1824, leaving among others a son, the late Charles S. Coxe, who was one of the judges of the District Court of

Philadelphia some sixty years ago, and the father of the subject of this sketch.

Eckley Brinton Coxe was born in Philadelphia June 4, 1839. He graduated from the University of Pennsylvania in 1858. After completing a course in the scientific department of that institution, he was engaged six months in topographic geological work, in the anthracite coal region of Pennsylvania. In 1860 he went abroad to continue his studies. The next two years were spent at the Ecole des Mines in Paris, and then a year in the Bergakademie at Freiberg, Saxony. He subsequently spent two years in visiting and studying the practical operation of the mines of England and the Continent.

With his brothers he inherited large coal estates in Pennsylvania, and his entire education had been directed with the special object of preparing him for their management. Consequently upon his return to the United States in 1865, Mr. Coxe, in company with his brother, under the firm name of Coxe Bros. & Co., began the business of mining anthracite coal in the Lehigh region. Since that time he has been engaged in the operation of his company's collieries.

In the operation of these mines he has won a high reputation, as one of the most progressive, able and honorable representatives of the great coal mining industry.

For many years Mr. Coxe has made his home in Drifton, Luzerne county, near to his mines and to the homes of his miners and workingmen. It is doubtful whether at any place in this country, an employer of labor has taken more pains and more pride than have been taken by Mr. Coxe and the other members of his family at Drifton, to minister to the wants and laudable ambitions of his workingmen, and to establish those cordial relations of respect, confidence, and friendship which should always exist between labor and capital. Like most other coal operators, however, Mr. Coxe has had his share of strikes and labor troubles, but he deserves the credit of having conducted the contests in such manner as to retain the respect and confidence of his men. His mines were idle in 1889 during the disastrous strike in the Lehigh region, but notwithstanding this fact, when he reached Drifton upon his return from Europe in October of that year, he met with a most enthusiastic reception from some five thousand of his employes and neighbors.

Mr. Coxe has always been a consistent and ardent Democrat, and in 1880 was elected to the Senate of Pennsylvania from the Twenty-sixth Senatorial District, composed of the lower part of Luzerne county and part of Lackawanna county. He did not take his seat as Senator, declining to take the oath of office prescribed by the Constitution, which included the clause that the candidate-elect had not spent money for election purposes other than for the purposes "expressly authorized by law." In a manly letter to his constituents Mr. Coxe stated that he could not honestly take this oath, and explained his election expenses and the reasons for his action. His constituents accepted the explanations in the same spirit in which they were given and in 1881 he was re-elected to the Senate by a majority over three times as large as that which he had received the previous year. His intimate acquaintance with the great industries of the State, his knowledge of practical business, his unquestioned integrity of character and honesty of purpose made him a model Senator, and extended his reputation over the entire Commonwealth. Mr. Coxe retired from the Senate in 1884, since which time he has refused all offers of public office, although he has continued to take an active part in the work of his party.

Mr. Coxe is a member of other engineering and scientific bodies besides the two of which he has been chosen president, among them the American Society of Civil Engineers, the Engineers' Club, and the American Association for the Advancement of Science. He was one of the vice-presidents of the last named at its New York meeting in 1887.

In 1889, he was vice-president of the Mining Congress held in Paris at the Exposition. He has been a director of the Philadelphia and Reading Railroad Company, and is at present president of the Delaware, Susquehanna and Schuylkill Railroad Company, a road built by his colliery company to connect its mines with the several anthracite roads.

Mr. Coxe is a man of unusual physical and mental energy, of indefatigable perseverance and industry, as well as uncommon versatility. He is genial and hospitable, a fluent and charming talker, with an attractive presence that never fails to please all with whom he is brought in contact, socially or otherwise.

He is a great friend of young men. The writer of this found him two years ago taking a brief relaxation from business by delivering a lecture to the students of Sibley College, Cornell University, on some points in the mechanical engineering of coal preparation. The lecture was a brilliant one, and it appeared to afford him as much enjoyment as it did his hearers.

As an engineer his skill is shown in the management of his collieries, and in the construction of the machinery for the preparation of anthracite coal. In his enterprise and foresight in adopting the highest class of machinery to cheapen cost of production he leads all his business rivals. He was the first to build entirely of iron and steel the huge "breaker" used to sort the sizes and clean anthracite coal, so as to avoid the risk of fire and lessen the repair attendant upon the old-fashioned wooden construction. This breaker he has described in a paper in Vol. XIX of the "Transactions of Mining Engineers," entitled "The Iron Breaker at Drifton," occupying 75 pages of the volume, with numerous plates of working drawings. The paper is remarkable for its vast detail of description of machinery, much of it Mr. Coxe's own invention, and it constitutes what is probably the most thorough treatise in existence on the subject of the preparation of anthracite coal.

This sketch of Mr. Coxe's career would not be complete without some mention of his labors in the direction of educating the youth of a mining community, or such portion of them as have an inheritance of brains which will enable them to absorb instruction, so as to fit them to become foremen, and intelligent and skilled workmen.

In 1879 he established an industrial school for young miners at Drifton, placing it in charge of the late Oswald Heinrich, an able mining engineer, who conducted it until his death in 1886.

Mr. Heinrich contributed a description of the school to the "Transactions of the Mining Engineers," Vol. IX, but the theory upon which the school is founded is best given in Mr. Coxe's own words in his presidential address before the Institute in 1879, on the subject of "Secondary" Technical Education (Vol. VII, p. 218).

We end our sketch with a quotation from this address, which shows not only Mr. Coxe's ideas on industrial training, but also his literary skill, and philanthropic feelings toward his workmen :

"We have many advantages—a country of great resources, cheap land, cheap coal, cheap raw material, cheap food, intelligent workmen, plenty of room for development, and in many respects a good government, well suited to foster such industries; but we should not be satisfied with this. We should endeavor to strengthen our position by educating as well as possible the engineers who are to plan and superintend our works, by training both theoretically and practically the foremen who, coming from the ranks of the workmen, will act as a link between the school-trained engineer and the latter, understanding, as they will do, the feelings, the ideas, the aspirations, the strong points and the weaknesses of those by whom the actual labor must be performed, and who form the basis of successful industry. With good engineers, with such foremen instructed sufficiently in theory to understand and carry out any process they may be put in charge of, having the respect not only of those over them, but also of the

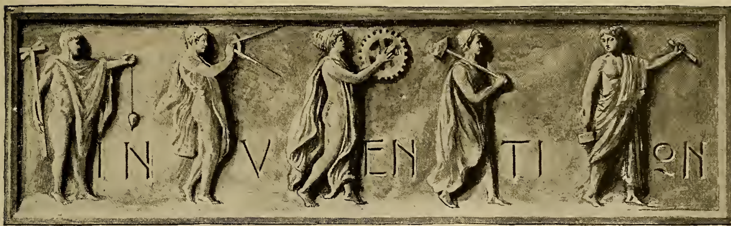
men under them, looking forward to their gradual advancement as their years of service and experience increase and with intelligent workmen such as our country already has and will continue to produce, we can, by carefully utilizing all our natural advantages, establish mining in that wide sense in which it is understood by our Institute, as one of the surest, most enduring, and most important elements of the prosperity of our country.

"To some, indeed, it may at first appear that the experiment is a dangerous one; that we are treading upon unknown and treacherous ground; that we may be sowing the seed of future trouble; that instead of good foremen, we may only make discontented workmen; and they may quote to us Pope's well-known lines:

'A little learning is a dangerous thing,
Drink deep, or taste not of the Pierian spring.'

But, gentlemen, while regarding Pope as a great poet, and, in many respects, a keen observer of human nature, I must take issue with him here, for to me it seems that true knowledge, however small the amount may be, can never be dangerous. It were better if we cannot drink deep, to put but one drop to our parched lips, rather than never to taste of its waters. It is false learning, be the amount great or little that, mingling with the truth, and corrupting it, causes the danger; and it is for the purpose of preventing the workmen from imbibing false ideas and opinions, so many of which they now drink in when acquiring practical knowledge, that I advocate the introduction of these schools. Educate the people, educate your foremen, educate your engineers, strive to give to every one some drops, however few, of the water of true knowledge, and we need not be anxious as to its effects, if it is pure, and contains no germs of corruption. * * *

"The great point to be gained by the establishment of such schools, is not only the building up around us of a set of foremen thoroughly trained, both theoretically and practically familiar with the details of their business, with a strong *esprit du corps*, with a feeling of pride in the works which they have educated, and with an interest in them that no salary or wages that they might be paid could alone give them. This is a great thing for the owners of the works and for their business success; but there is a point of much greater importance. Brains, though rare, are not distributed by any known rule among the people. A Stephenson may be born in the cottage of a common miner, and rise to teach the world the profession of engineering. A Franklin may force his way from a printers' case to the position of a great statesman and a great physicist. There are but few men of ability born each year; but they are as likely to be found in the humblest dwelling as in the palace."



NOTES ON NEW AND PATENTED INVENTIONS.--III.

By John Richards, President of the Technical Society of the Pacific Coast and Editor of "Industry."

THIS is the third of a series of articles in which it is intended to review various inventions that have a general interest or mark an advance in the arts to which they pertain.

British Patent No. 11,776, 1891.

NEWTON—RAILWAY BRAKES.

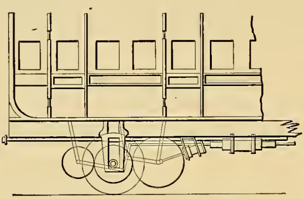
This patent describes an attempt to utilize the momentum of a railway train in applying brakes on the wheels, the resistance being produced by means of revolving frictional discs or wheels pressing on the wheels of the carriages, and their rotation opposed by pistons acting on air. The scheme involves a good deal of detail, and, aside from any practical merit, is an interesting study for those connected in any way with the subject of brakes, inasmuch as it is an attempt to avoid "sliding action," the common means of producing brake friction. The purpose in alluding to the patent is not to comment upon the merits or limitations of the method, but as a text for some remarks upon the principle involved, and to say that the failure thus far to employ the momentum of trains in applying brakes seems an anomala in modern mechanical achievement. There is present a powerful force commensurate with the brake resistance required, not only force, but moving developed energy communicated to rotative parts, and available almost in the same degree as is the torque of an engine or water-wheel shaft.

The elasticity, or variation of position, between the body of carriages and the axles and wheels on which they rest, is an impediment of more importance than would appear from inference, a matter proved by the difficulties of our time in transmitting from electric motors to the axles of railway cars, but such impediment is fast disappearing in the case of driving motors, and is certainly a much easier problem than the transmission of power from an axle to such mechanism as would be required to set railway brakes. Of course any communicating, or "throughout," system where the brake power, or setting force, must be uniform, and nearly instantaneous throughout a train, is best performed by air, and the exigencies of use are such that the economy of energy, or cost, is hardly to be considered, but there is a wide field in street lines alone, where pneumatic brakes are not employed, and where it seems that the momentum should be utilized for braking at least, if not stored as a re-starting force.

We know the theme is an old one, and its history, so far as attempts have been made, is one of complicated and impossible contrivances. There is also the

fact that mechanism of any kind for such a person must be dragged through the streets, so to speak, covered with sand and grit, and that it must, in any case, involve a great deal more detail than simple shoes pressed against the wheels by toggle gearing, but the question arises, have the limitations of the system been reached?

The storing or accumulating expedients common in mechanics are, com-



NO. 11,776. RAILWAY BRAKES.

pressed springs, compressed air, and elevated weights. Springs are liable to fracture and change of tension or resistance. Compressed gases require fits almost impossible to maintain beneath a car, and weights are out of the question, so that at the very outset there are set up discouraging conditions of a very serious kind. The patent at first cited adds a new principle, or "mode of operating."

Patent No. 472,432, April 5, 1892.

H. P. CHRISTIE—FRICTION CLUTCH.

The invention of friction clutches has, for ten or twelve years past, gone on at a rate that would lead one to suppose the subject exhausted in a mechanical way, and that nearly all the expedients possible had been resorted to. This may be true, but the diversity is far from showing an intelligent research. One reason of this is not far to seek. Clutches have no literature to speak of, and the various modifications are produced by contriving, without certain definite ends in view.

This paucity of general information on the subject is proved by a remark made to an Eastern friend at Philadelphia some years ago, that the makers of mill gearing in the East should furnish clutch pulleys for driving dynamos that would have no running joints when the dynamo was not in motion. The speaker was informed that "such a thing was not possible." The fact is that if a specification for clutches was drawn with this requirement, there are very few works in this or any other country that would know how to execute such an order. Still it is possible, a matter of regular practice on the Pacific Coast, and the present patent is cited to show one method of making such clutch pulleys without running joints when unclutched or free.

It is a common and almost universal practice to mount the pulley to be clutched loosely on the shaft, where it rests when out of use, equivalent to a running bearing, sustaining the strain of the belt on one side, and requiring constant and careful lubrication. It is not only equivalent to a bearing for the shaft, in respect to speed, area and strain, but has not the advantage of wearing to a fit, as in the case of a journal. The shaft is worn on one side, and the fit distorted. The more the wear the worse the fit, so that, in point of care and risk, one loose pulley of the kind causes more difficulty than three common journals on the same shaft.

Referring now to the diagram, it will be seen that the pulley *A*, when not in use, does not rest on the shaft at all, but on two brackets or collars *B* and *C* that are bolted to the ceiling, or on a foundation, the same as the hangers or pedestals on which the shaft is mounted.

The pulley has an enlarged boss, or second rim it may be called, which takes its bearings loosely within the brackets or standards *B* and *C*.

The clutch mechanism consists of two jaw plates, one at each side, both free to slide on the shaft and the keys seen in front. These jaws or gripping plates are drawn together by bell cranks and links operated by a common toggle apparatus and sliding col-

lar, shown at the left and understood without further explanation.

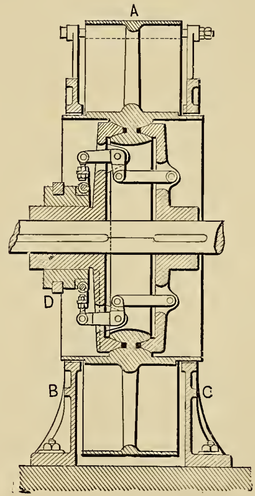
In this manner the clamping strain is opposite and equal on the gripping faces, and the parts adjust themselves when the clutch is engaged. The stationary brackets *B* and *C* are bored out a little larger than the diameter of the hub or boss of the pulley, so that when the jaw plates are closed and the pulley starts, it is at once moved free of its stationary supports and brought concentric with the shaft, so that the adjustment of the brackets is not a matter of precision as might be supposed.

When the gripping plates are loosened the pulley at once takes its bearing on the brackets, and there is then no sliding or running bearing except the collar *D*, that moves the toggle joint. There is neither contact, wear, nor lubrication, and the shaft is relieved of the strain of the belt, so that no attention whatever is required when the clutch is out of use.

Previous to adopting this form of clutch pulleys, Mr. Christie employed for similar purposes telescoping pulleys, having the same functions in respect to strain, running joints and so on, but the mechanism was more expensive. In that case there was a stationary pulley, it might be called, mounted on a fixed bracket or support. Fitting closely over this fixed pulley was a movable and running one, having the edge of the rim chamfered off to an edge, so it could be shoved under the belt raising it from the fixed pulley, in other words the movable pulley took the place of the fixed one while the belt was in motion, and was slid out leaving the belt on the fixed one when out of use.

In the present invention the supplementary fixed bearings for the pulleys are the main feature, and the performance in practice is very satisfactory and a great advance on any method that leaves the stress of a belt to fall on a boss or hub, bearing upon a running shaft.

In respect to clutches in general there seems to be, especially in England, a total neglect of the fact that the traction power of frictional surfaces is as their distance from the centre of rotation, or in other words, as their speed; notwithstanding this, we see the diameter of friction clutching mechanism reduced down to the smallest dimensions and applied even around the hubs or pulleys. This has the unimportant advantage of the friction the surfaces coming in contact at a lower velocity, and also reduces the size and weight of parts, or appears to do so, if the tractive force is not as it should be, estimated as the measure of capacity.



NO. 472,432. FRICTION CLUTCH.

Small diameter or slow speed calls for corresponding intensity of pressure, and this causes a like wear of the faces, because slipping is unavoidable, indeed slipping is an essential function of all friction clutches, without which they would be inoperative as such, and correspond to the old positive jaw type, now nearly out of use. Present progress is also indicated by the abandonment of what may be called the non-equalizing types, wherein the force that presses the friction surfaces together was taken up on a fulcrum or abutment

independent of the faces, and not "balanced" as it is called. This was commonly done by toggle struts that bore at their inner ends against the hub of a pulley or wheel, or a collar on the shaft and within the outer rim of the wheels. The subject is an extensive one and may be taken up again at a future place, pointing out now, however, that the most important and most perfect type of friction clutches and those most commonly employed are, with certain limitation, "shifting belts." One seldom thinks of a shifting belt as a friction clutch, but it is nevertheless, in all essential features, and so perfect that no other device of the kind can compare with it.

The frictional surfaces in contact are commonly leather and polished iron, a combination the best that has ever been discovered. The frictional surfaces are so long or so extensive, and operate under conditions that avoid heat, which is an impediment in all other clutches, especially those of high speed, and to transmit a large amount of power. The pressure is elastic, cumulative, and increases with resistance, which is not the case with common friction clutches. The engaging force is inherent and automatic. There are no toggles, levers, or other apparatus requiring effort; the spiral winding of the belt accomplishes all except the slight force to "direct" it. Viewed in this manner it is not hard to account for the survival and almost universal use of shifting belts to stop and start machinery.

It can also be seen that friction clutches with metallic faces are frequently applied when they are not required, and when shifting belts are preferable every way, on the countershafts of lathes, for example, to reverse the motion. The reason for this is that as usually arranged, the time required to shift a belt prevents accuracy, or is not sudden enough to meet the conditions of screw cutting. This fault is easily remedied by making the belts narrower, increasing the diameter of the pulleys and increasing the speed of the belts. If, for example, a lathe belt is made, one two inches wide instead of four inches, and the pulleys are two feet in diameter instead of one foot, the time of shifting or reversing is not only reduced one half, but a good deal more, because edge flexure of a belt is inversely as the square of its width.

In this last named fact we found the principal limitation of shifting belts, which confines them to a small amount of power. There is also the wide space required for double pulleys that becomes a serious impediment in most cases.

U. S. Patent No. 166,676, Aug. 10, 1875.

ATKINS—WATER WHEELS.

Continuing in digression from recent inventions, the patent above will form a proper subject for some remarks at this time, especially as there is much present interest in the subject of impulse water wheels. In a letter written recently to the editor of Power, it is claimed that the above named patent is an anticipation of what is called the Pelton water wheel, a conclusion that there seems no warrant for, especially as an analysis of the Atkins wheel by any competent hydraulic engineer will hardly ascribe a duty of 50 per cent. to the Atkins modification. The plan diagram shown gives a very clear idea of the mode of operation. *A* is a volute chute from which water is discharged to, or forced into, the reversed apertures in the rim of the wheel, and discharged inward, both inlet and discharge being as nearly tangential as possible.

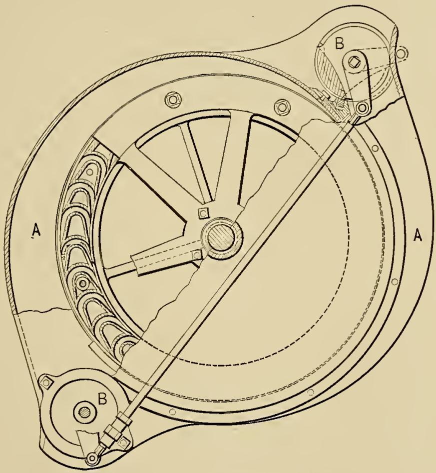
In respect to a comparison with modern impulse wheels, there is found, in the words of the patent above cited, a good deal to warrant the conclusion of the writer before named, but not enough. In the first place, impulse wheels operating on the principle of the Pelton type are not new, and antedate by at least a score of years the patent of Mr. Atkins. We do not mean "flutter" wheels, undershot ones and so on, but those in which the water was discharged by clear impinging jets against the vanes, the Girard type is one of these, and even centuries earlier were the tub impulse wheels with flat oblique vanes. The Pelton wheel is

one with a straight cylindrical jet, delivered under all the conditions that will insure maximum or theoretical effect with vanes or buckets that split the jet and reverse its course as nearly as possible tangential to the wheel's course and clear of it.

None of these conditions are fulfilled by the Atkins wheel, nor by the Girard types. The jets are not cylindrical, which is the form of greatest effect. The course of the jet is not completely reversed in the Girard, is nearly so in the Atkins wheel, but against centrifugal force, and is left tangled up in the wheel, so to speak. The efficiencies are as these conditions indicate. The Pelton wheel gives a maximum efficiency that, no doubt, exceeds all forms of previous impulse wheels, also filled or pressure turbines. Mr. R. D. O. Smith, the writer before named, whose address is not given, says that, so far as he has observed, the reason of this efficiency has never been explained. If he were to hear a discussion on the surface resistance in nozzles of various forms, and the friction of wetted surface in the buckets, with nice distinctions of angles, by the engineers on the Pacific Coast, he would change his mind.

That portion of the patent of Mr. Atkins bearing upon open or unfilled wheels is worth quoting here as follows:

"It was stated above that the aggregate sectional area of all the channels between the buckets should be double that of the two chutes in the trunk, through which water is supplied to the wheel. In connection with the above, I will make the further statement that the velocity of the wheel, in order to obtain the maximum amount or power, or an amount equal to the whole momentum of living force of the water acting upon it, must equal one-half the velocity of the water at the instant of contact with the buckets.



NO. 166,676. WATER WHEELS.

I will next undertake to explain why it is necessary that the aggregate sectional era of all the channels through the buckets should be equal to twice that of the chutes.

Suppose, now, that the wheel is barred so that it cannot move, and that the gates are opened ; we shall find that as the water flows through the buckets with the same velocity as in the chutes, so long as the wheel remains station-

ary, the water will only one-half fill the water channels, the remaining one-half of each channel remaining empty ; but on allowing the wheel to run with its maximum speed of half that of the water, the velocity of the water in its passage through the buckets will be only half what it was while the wheel remains stationary. Therefore its volume will be double, and consequently will exactly fill the channels, thus excluding all backwater from the wheel, which, were it allowed to be carried around with it, would, by its centrifugal force, greatly impede the passage of the water through the buckets, and thus reduce the power of the water upon the wheel."

These propositions can be understood by referring to the diagram at the beginning. The volute chutes surrounding the wheel, represent, in a sense, jets, indeed become so, because of the reduced sectional area proposed, and the wheel, as distinguished from a pressure turbine, is one wherein impulse takes the place of pressure, because of the contraction of the chutes. Here analogy ceases, because even in the Girard multivent chutes there is a better application of the water, but an inferior form of buckets compared to Atkins, especially if the latter opened outward instead of inward. It is a good wheel, however, comparatively speaking, for eighteen years ago, and under high heads will give a creditable efficiency. The reasoning above, in respect to the discharge through the wheel when still and when in motion, conveys or explains a principle in hydraulic motors not commonly understood, and one of a good deal of importance, applicable in other wheels.

U. S. Patent No. 475,026, May 17, 1892.

J. F. M. WOODS—REVERSING GEAR FOR ENGINES.

This invention is a reproduction in a much improved form of what is called a transfer plate between the face of a slide valve and its seat, so induction and eduction ports are transposed. One of its earliest recorded uses in this country was on some of the first Baldwin locomotives, at Philadelphia, where, as now remembered, it was introduced at the instance of Mr. Joseph Harrison, Jr.; at least he had in his possession, previous to his death, the patterns from which these transfer or transposing plates were cast. Perhaps an earlier use was on the cargo engines employed on the Mississippi River. The method is old, but is in the present invention produced in an improved form, these being longitudinal and transverse sections through the valve and transfer plate.

It is unfortunate that the requirements of steam distribution do not admit of economical reversing devices of the kind, or by means of changing the steam exhaust ports and the reverse, a difficulty vastly increased at this day when valve functions have become more and more an element in the economical working of steam engines. It is true the principal objection to mechanical reversing gearing is exposure and wear, which in most situations are not considerable, but in other cases a serious objection, so much so that it is better to abandon lap and lead to reverse by steam.

B. W. GOODSELL.

On another page is printed a portrait of Mr. B. W. Goodsell, who contributes in this issue a short article on the subject of "Piston-Rod Packings." At a future date a second article from Mr. Goodsell will be printed on this important matter, and as packing has so much to do with the economical running and wear of an engine, every engineer and manufacturer will undoubtedly find it of interest. Mr. Goodsell is qualified to write on the subject, being the inventor of and manufacturer for many years, at Chicago, of what is known to the trade as "rubber back flax piston-rod packing." Mr. Goodsell has made a special study of packings.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

By F. Houghton.

THE writer in a previous article has given the general facts of the inception of the Canadian Society of Civil Engineers, and it will be unnecessary to say anything more regarding its early existence. The history of the society, however, would not be complete without a reference to the Members of the Council, the able and efficient secretary, Professor C. H. McLeod, the treasurer, Mr. Wallis, and the librarian, Mr. McNab, and in this and another paper, the writer will give such facts regarding these members of the organization as will be of interest.

Professor C. H. McLeod, secretary of the Society, was born in Cape Breton, January 20, 1851. His early education was in the public schools, and in the Model and Normal School of Truro, Nova Scotia.

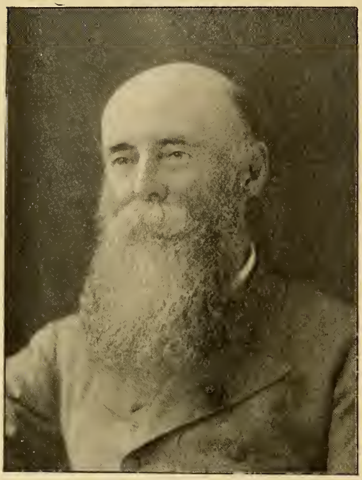
From 1867 to 1870 he was employed on the construction of a portion of the Intercolonial Railway, first as junior, afterwards as assistant, or section engineer.

In 1873 he graduated in the courses of civil engineering in McGill University, and afterwards accepted the appointment of resident or division engineer on the Prince Edward Island Railway, on the completion of which he was appointed Engineer of Public Works for Newfoundland, and while engaged on this work was offered the appointment of Superintendent of the McGill College Observatory. He was also appointed lecturer on several of the professional subjects in the Civil and Mechanical courses, which post he held for twelve years. His next appointment was that of Professor of Surveying and Geodesy, Faculty of Applied Science.

Professor McLeod is a Fellow of the American Association for the Advancement of Science, and has just completed the observations connected with the direct determination of the longitude of Montreal, by connection through the cable of the Commercial Company, with Greenwich, in co-operation with the Astronomer-Royal.

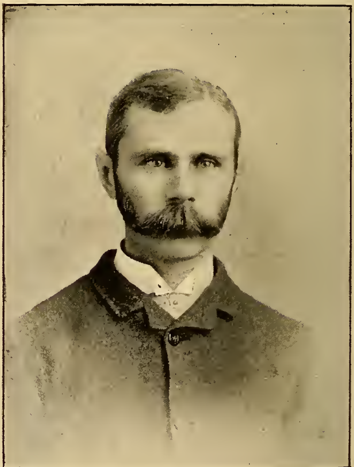
Of the members of the Council perhaps none was better or more favorably known than Mr. Frederic Newton Gisborne, who died on August 30 last. Mr. Gisborne was born at Broighton, Lancashire, Eng., 8th March, 1824. On his mother's side he received his second name from his famous ancestor, Sir Isaac Newton. He was educated by the Rev. R. Pidcock, vicar of Warslow, Staffordshire, Dr. Cowan, Foxleth Park, Liverpool, and Rev. W. Thompson, of Cheadle, Cheshire, assisted by special instructors in mathematics, civil engineering, botany, etc. In July, 1845, he arrived in Canada, and resided on a farm near St. Eustache until May, 1847. In Montreal he became one of the first operators of the Montreal Telegraph Company, and for that company opened an office in Quebec. The British North American Electric Telegraph Association was then formed for the purpose of connecting the maritime provinces with the Canadas, and with the consent of the Montreal company Mr. Gisborne was appointed general manager of the association, and was deputed to visit New Brunswick and Nova Scotia, where he explained the new science to the legislatures, then in session, and lectured before the public on the value of telegraphic communication throughout the continent. His mission was so successful that the government of Nova Scotia undertook to erect a line from Halifax to Amherst, conditionally upon Mr. Gisborne's services being transferred to them by the association which he represented. This request was finally agreed to, and from the spring of 1849 to 1851 Mr. Gisborne was superintendent and chief operator of the government lines at Halifax. In 1850, during

the winter, he visited Newfoundland with the object in view of connecting the island with the mainland by telegraphic communication. When there



FREDERICK NEWTON GISBORNE, C. E., M. I. C. E., F. R. S. C., DECEASED AUGUST 30, 1892, MEMBER OF COUNCIL.

he contracted to erect a land line between St. John's and Carbuisar, via Harbour Grace, which he completed the following summer, and started in September with six men to survey a practical route across the widest and most rugged section of Newfoundland, from St. John's westward to Cape Ray. This survey he completed successfully. During the winter session of 1851–'52 the legislature granted to Mr. Gisborne and his associates a telegraphic construction charter, with exclusive privileges for the term of 90 years, on account of which Mr. Gisborne resigned his superintendency and a good salary to carry out the enterprise which he had himself projected and initiated. He then visited New York, and there obtained an assurance of all the capital required from Horace B. Tibbetts and D. B. Holbrooke, both of that city, and from Thomas C. Dexter and General John Tyler, of Boston, and upon his return to Halifax laid before the Hon. Joseph Howe, Secretary of State for Canada, the then astounding and apparently chimerical project of a transatlantic submarine cable connection between Newfoundland and Ireland. The letter from Mr. Howe and the published correspondence between J. W. Brett and Mr. Gisborne, in the early part of 1852, are proof positive that to Mr. Gisborne and to Canada is due the credit of the conception and primary practical movement for transatlantic telegraphy, and, if further evidence be required, note an appendix to the Rev. Mr. Harvey's text-book of the history of Newfoundland. On the 20th November, 1852, Mr. Gisborne laid the first ocean cable on this side of the Atlantic, connecting Prince Edward's Island with New Brunswick. During the winter of 1853–'54 Mr. Gisborne met for the first time Mr. Cyrus W. Field, whose name since has become famous



W. MCNAB, LIBRARIAN.

in connection with the transatlantic cable. In 1857 Mr. Gisborne abandoned telegraphy *pro tem*, and returned to Newfoundland, where at a

C. H. MC LEOD, SECRETARY CANADIAN SOCIETY OF CIVIL ENGINEERS.

public dinner he was presented with a valuable silver statuette, as a testimonial of the high esteem in which he was held by the community of New-

H. WALLIS, M. INST. C. E., TREASURER.

foundland. Then for several years he devoted himself to mining pursuits, during which time he explored the island eastward around the coast, from Cape Ray to the Straits of Belle Isle. Returning to London, he had the honor of representing the interests of Newfoundland as acting commissioner at the great exhibition of 1862, three years later representing the colony at the Paris exhibition of 1867. During this time Mr. Gisborne became noted for the number and variety of his inventions, for which nine medals were awarded. Among the inventions were his electric, pneumatic, and mechanical ship signals, anti-corrosive and anti-fouling compositions for the bottoms of iron ships, the electric recording target, improvements in gas illumination, etc. I may here add that his semaphore was awarded a gold medal at the late fisheries exhibition in London. In 1869 he became chief engineer to an English coal-mining company. As a contractor he built the Torway to Louisburg Railway, with two shipping piers at Sydney and Louisburg harbors. In 1879 Mr. Gisborne accepted the superintendency of the Dominion Government Telegraphic and Signal Service, which position he up to his death occupied. Mr. Gisborne was one of the original fellows nominated to the Royal Society of Canada. He was also a member of the Institution of Engineers and Electricians, of London, Eng.

Herbert Wallis, the treasurer of the Canadian Society of Civil Engineers, was born in Derby, England, on 10th of March, 1854, and comes of a family which for many years was resident in Derby. For several generations the head of the family was engaged in the business of stage coaching. On the advent of railways his father, William Wallace Wallis, became one of the cartage agents of the Midland Railway, from which he retired some years before his death, in favor of one of his sons. Her-

C. H. KEEFER, MEMBER OF COUNCIL.

bert Wallis was educated at a commercial college near Halifax, England, where he had a special training in that branch of the profession which he at

present follows. On the completion of his college career he became a pupil of Matthew Kirtley, then locomotive superintendent of the Midland Railway,

HENRY T. BOVEY, M. A. INST. C. E., MEMBER OF COUNCIL.

where he was engaged in the drawing office and workshops of the company, in his native town, Derby, till August, 1866, when he was appointed foreman of the locomotive and carriage department at Bradford, Yorkshire. In March, 1871, he accepted the position of assistant mechanical superintendent of the Grand Trunk Railway, offered to him by the president, Mr. Richard Potter, and sailed for Montreal on 4th May of the same year. In January, 1873, he was appointed chief mechanical superintendent, which position he still occupies. Mr. Wallis is a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers of England.

C. H. Keefer is the eldest son of Thomas C. Keefer, of Ottawa, and was born the 7th May, 1851, at Rideau Hall, the residence of his grandfather, the late Hon. Thomas Mackay. In 1869 Mr. Keefer began the practice of engineering on a preliminary survey for the Ottawa water works, and in the same year was on another under the Public Works Department. In 1870 he was engaged on the construction of the Canadian Central Railway between Ottawa and Carleton Place, and in 1871 on the construction of the Chaudiere branch of the St. Lawrence and Ottawa Railway. From 1871 to 1875 Mr. Keefer was engaged on the construction of the Ottawa water works, and for the next two years employed on the location of surveys for the Canadian Pacific Railway in the Yellow Head Pass of the Rocky Mountains, B. C. From 1878 to 1881 he was employed on harbor works and the surveys of the ship channel between Montreal and Quebec, and on the construction of the Lorne bridge, Branford, another railway bridge work. From 1881 to 1884 he took charge of the engineering work on the location and construction of branches of the New York, Lake Erie and

P. W. ST GEORGE, MEMBER OF COUNCIL.

Western Railway, and of the construction of the well-known Kinzua viaduct, 301 feet in height and 2053 in length. After this work was completed his labors

were on the construction of the Canadian Pacific Railway in the Kicking Horse Pass, B. C., and general practice in Toronto, where he now resides.

Professor Henry Taylor Bovey is a native of Devonshire, and was educated at a private school in England and at Cambridge University. On entering the university he competed for and obtained an open scholarship. On graduation he took a high place in the mathematical tripos, and shortly afterwards was made a fellow of Queen's College. Having decided to adopt the profession of civil engineering, he joined the staff of the Mersey Docks and Harbor Works. In a short time he was appointed one of the assistant engineers on this work, and in this capacity had charge of some of the important structures then in progress. In 1877 he accepted the appointment of professor of civil engineering and applied mechanics in McGill University. At that time the engineering courses in the university were managed as a branch of the faculty of arts, and were without buildings or equipment. The following year, however, a department of applied science was constituted, and Professor Bovey was elected its dean. The recent magnificent endowments to the university have afforded Dean Bovey an opportunity for the display of his great executive ability and untiring energy. The University of Bishop's College has quite recently conferred the degree of D.C.L., *honoris causa*, on Professor Bovey. Much of the success of the Canadian Society of Civil Engineers is without doubt due to his labors as its secretary, which position he occupied continuously from the foundation of the society until within the last few months, when increasing college duties compelled him to resign the office. Professor Bovey is a fellow of the Royal Society of Canada, a member of the Institution of Civil Engineers, a member of the Institution of Mechanical Engineers, and an honorary member of the National Electric Light Association of the United States. He is also a member of the Liverpool Society of Civil Engineers, being one of the three original founders, the other two being C. Graham Smith, now dead, and W. W. Squire, now harbor engineer at Bombay.

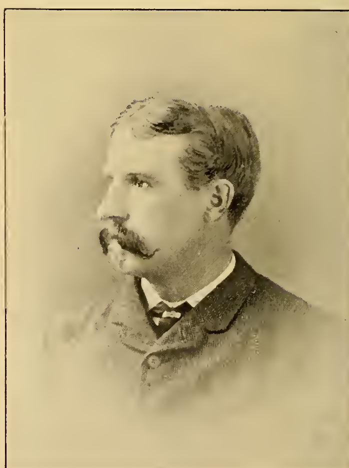
Percival W. St. George is an Englishman by birth, and he began his career as a pupil of Alexander McNab, who was then chief engineer of the province of Nova Scotia, with whom he remained two years, from 1866 to 1868. From 1868 to 1872 he was assistant engineer on construction and survey of the Intercolonial Railway, of Canada. In 1872 became engineer on the survey of the North Shore Railway, of Canada; from 1873 to 1874 was engineer on the maintenance of way on the Intercolonial Railway; from 1874 to 1875 was on the survey of the Northern Colonization Railway; from 1875 to 1876 was assistant engineer of Montreal, and from 1876 to 1883 deputy city surveyor of the same city; from July to December of 1883 was engineer on the Norfolk and Western Railway, in Virginia. In 1883 Mr. St. George was appointed city surveyor of Montreal, which position he at present occupies. In 1886 he was elected a member of the flood commission of Montreal, and in 1887 became a member of the Institution of Civil Engineers, of England.

Mr. E. H. Hoare, who is a member of the council, served his apprenticeship with Mr. Joseph Wilson, a civil and mechanical engineer of London, England. He came to Canada in 1869, and took the position of assistant engineer on the Toronto Grey, and Bruce Railway, afterwards holding the same position for a number of years on the Great Western Railway, of Canada. He then became resident engineer in charge of a portion of the construction of the Wellington, Grey and Bruce "Air Line." He then went to Quebec to take the position of first assistant to the chief engineer of the Provincial Railway System, later on having charge of the works in Montreal, and on the east and west divisions until they became the possession of a syndicate. From that time Mr. Horace has had charge, as chief engineer, of several pieces of construction, among others the Quebec, Montmorency and Charlevoix Railway surveys for the local

government works, and of the water works constructed at Quebec by the well-known contractor, Mr. Beemer. For the past four years he has been in charge of the construction of the Quebec and Lake St. John Railway. Mr. Hoare, besides being a member of council for the Canadian Society of Civil Engineers, is an associate member of the Institution of Civil Engineers of London, Eng.

H. N. RUTTAN, MEMBER OF COUNCIL.

Mr. H. N. Ruttan is a Canadian by birth, and was educated at the Cornwall and Cobourg Grammar School. In 1867 he became a member of the engineering staff of the Grand Trunk Railway, and was engaged in 1869 on surveys for the Intercolonial Railway. From 1870 to 1874 he was employed on the construction of the Intercolonial Railway, having charge of a division on the Bay de Chaleur. In 1874 Mr. Ruttan left the Intercolonial on the completion of his division, and entered the employ of the Canadian Pacific Railway Company, taking part in the surveys along the north shore of Lake Superior. In 1875 he had charge of a location party for the same company through the Yellow Head Pass of the Rocky Mountains. From 1877 to 1880 he was engineer for the contractors on the construction of the C. P. R. between Lake of the Woods and Winnipeg. From 1880 to 1885 he was occupied in private practice in Manitoba, and during that time built a bridge over the Red river at Emerson, also one over the Assiniboine at Winnipeg. As engineer and contractor he built the first 40 miles of the Manitoba and Northwestern Railway; also, in the same capacity, the first 50 miles of the Manitoba and Southwestern Railway. In 1885 Mr. Ruttan was appointed city engineer for Winnipeg, which position he at present occupies. Among other works while in this important position may be mentioned an exhaustive report which he made on the water power of the Assiniboine river. He built the water works for Calgary, and a system of works in Regina; made plans and report for sewers for the town of Brandon, and constructed water power works for the etectric light company of Rat Portage. Among his many other duties at Winnipeg he su-



C. E. W. DODWELL, M. INST. C. E, MEMBER OF COUNCIL.

pervises the construction of about five miles per annum of sewerage system in the city, and is now undertaking a new and extensive system of water works.

C. E. W. Dodwell, B. A., has been a member of the council for the past three years. He is a son of the late Rev. G. B. Dodwell, M. A. He was born in England in 1853. In 1862 he came to Canada and began his education at Bishop's College School, Lennoxville, finishing at King's College, Windsor, Nova Scotia, where he took a full course of engineering and the degree of bachelor of arts, with high honors in mathematics and natural sciences. From 1873 to 1877 he was employed as assistant engineer on the location and construction of the principal lines of railways in Nova Scotia—namely, the "Western Counties," the "Nova Scotia Central" and the "Eastern Extension" Railways. In 1877 he was appointed assistant provincial engineer under the government of Nova Scotia. This position he resigned in 1881 to accept an appointment upon the staff of the Canadian Pacific Railway in Montreal. Mr. Dodwell was in the service of this company for about eight years, and during that time was engaged almost exclusively upon construction. The preliminary surveys and estimates for the St. Lawrence bridge were his first work, performed in company with Mr. G. H. Massey, M.C.S.C.E. He was next employed upon the construction of the Ontario and Quebec Railway, first in the position of section engineer, subsequently in charge of the construction office in Toronto. He was next resident engineer in charge of that portion of the C. P. R. from Montreal to Vaudreuil (24 miles), which comprised some heavy work—namely, the large stone viaduct entering the city and the bridges, 33 spans of steel, over the Ottawa river at St. Anne's and Vaudreuil, on which latter work he submitted a very clever paper to the Canadian Society of Civil Engineers in 1888. (See Vol. II, Part I.) In 1889 he resigned his position in the C. P. R., and in partnership with Mr. A. L. Hogg, M.I.C.E., M.C.S.C.E., established the firm of Dodwell & Hogg, for a general engineering practice. Occupying his time at this period may be mentioned the water works and sewerage systems of Dartmouth, and the water works of Amherst, Nova Scotia. In 1891 he accepted an appointment under the federal government as resident engineer of the Public Works Department, at Halifax, Nova Scotia, which position he still occupies. Mr. Dodwell was elected an associate member of the Institution of Civil Engineers in 1881, and he was transferred to the class of members in 1891. In 1887 he took an active part in the formation of the Canadian society, being one of the original Montreal committee.

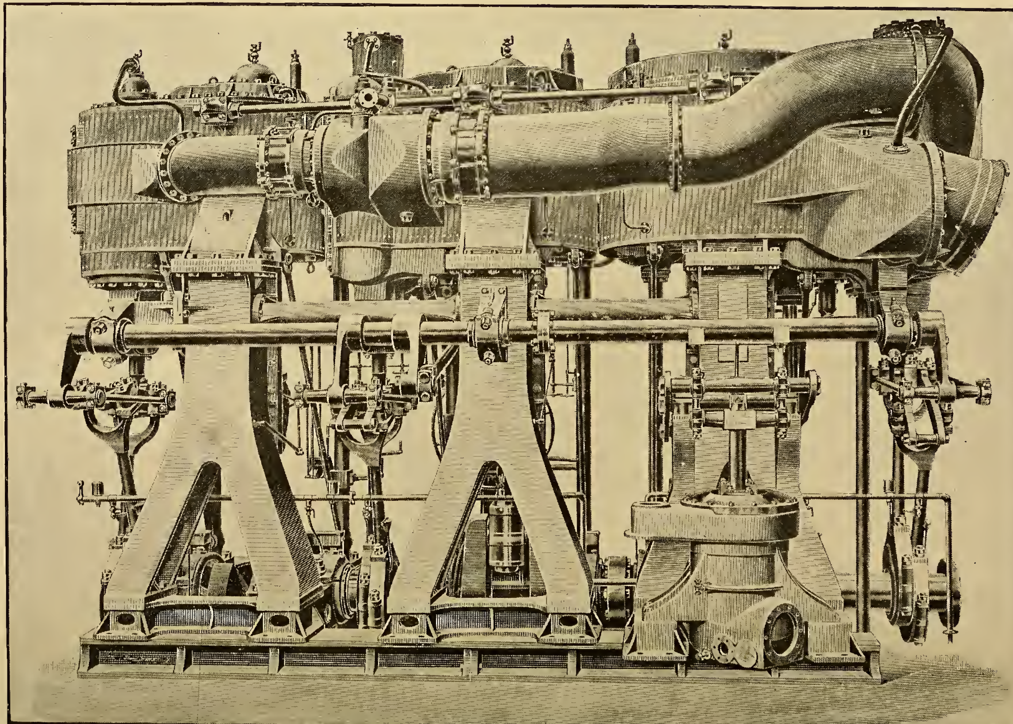
(*To be concluded in January issue.*)

B. W. GOODSELL.

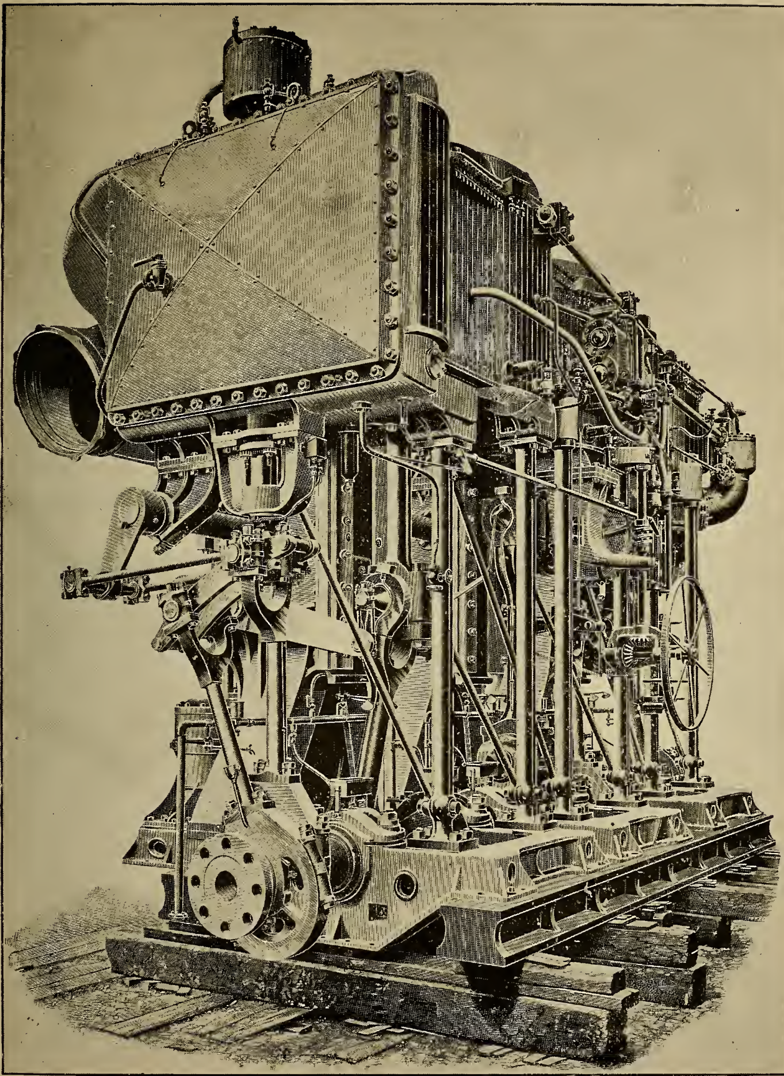
TRIPLE EXPANSION MARINE ENGINES.

THE engines of which several illustrations are herewith printed are vertical, of triple-expansion type, and drive twin screws. They were designed and constructed by the Palmer's Company under the direction of Mr. J. W. Reed, manager of the engine works, for H. M. Cruisers Pique, Rainbow and Retribution and have in their trial more than carried out the onerous conditions imposed by the British Government. Each set of engines is placed in a separate water-tight compartment, these being divided by a middle line bulkhead. The diameters of the cylinders are 33½ inches, 49 inches, and 74 inches, all with 39 inches stroke of piston. They are placed with the high-pressure cylinder forward, the intermediate pressure in the middle, and the low-pressure aft. The valve chests are placed on the forward sides of the high-pressure and intermediate cylinders and on the after side of the low-pressure cylinders, a piston valve being fitted to the high-pressure, while the intermediate pressure and low-pressure have double-ported flat slide valves, fitted with Church's relief rings in the back. The cylinders are quite independent castings but connected by bar stays and copper pipes. The breeches standards are also connected near their tops by struts. The liners of the high-pressure and intermediate cylinders are of steel, while that of the low-pressure is cast-iron. The pistons, together with the cylinder and valve-chest covers, are all of cast steel. This latter material is largely used in the framework of the engines. The back standards are of the split type of box section and of cast steel, with the piston-rod guides attached. The bedplate for each set is in three independent pieces, each cylinder having its own bedplate. These are of box form and of cast steel, and as will be seen from the illustration, both bedplate and standards are of a very substantial character. Each cylinder is supported at the front by two turned columns of forged steel, an additional column being placed under the low-pressure valve chest. A diagonal stay runs from the bottom of each front column up to the under side of the cylinders at the back, and the engines are further stiffened by an athwartship stay being carried from each cylinder top to a horizontal fore-and-aft girder formed on the middle line bulkhead. This makes an unusually stiff framework, and the intention of the designers was fully realized, for on the full-power trials, even when running 145 revolutions, there was not the slightest vibration even at the tops of the cylinders. The crankshaft is of steel, and in two pieces, with the cranks placed at 120 degrees apart. Both shaft and pins are hollow, the diameter of the shaft being 12¾ inches. The piston and connecting-rods, together with most of the gear, are of steel.

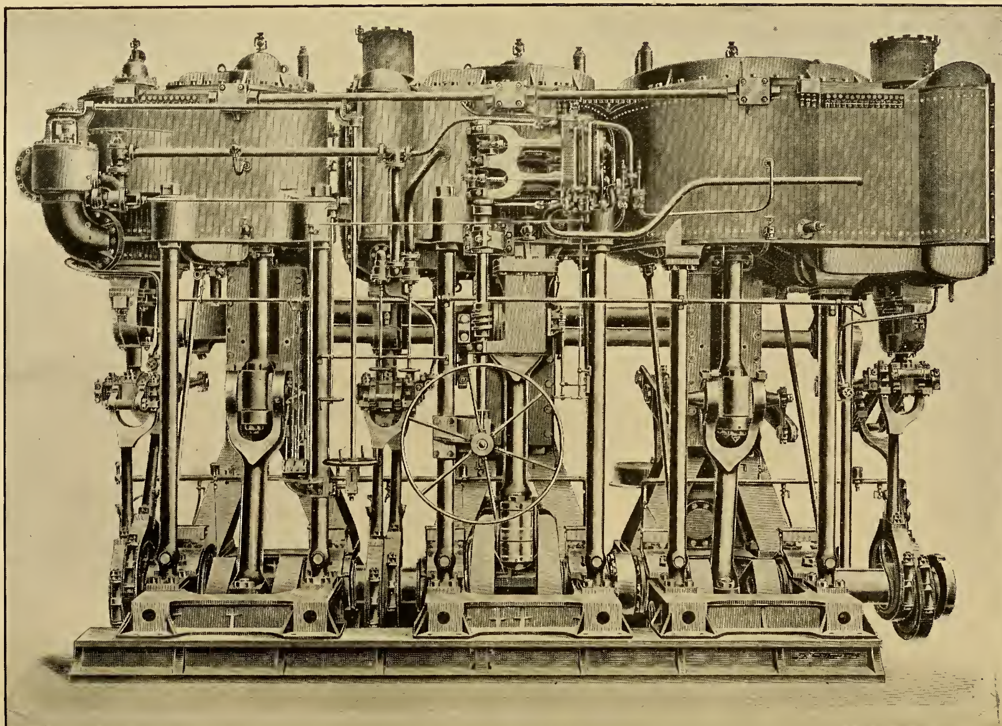
The valves are driven by ordinary link motion, with the reversing shaft placed along the back of the engines. The reversing engine has two cylinders, and is snugly placed on the front of the intermediate cylinder. The reversing gear is of the ordinary all-round worm and wheel type. The handwheel in front may be put out of gear when not required. The various handles and wheels are grouped together conveniently at the front. There is one single-acting air pump placed at the back of each low-pressure engine, driven by levers from low-pressure crosshead. The condenser is of cylindrical form, of cast gun-metal, and placed at the after end of the engines. The diameter of the body is 6 feet 6 inches, and the length 8 feet. The total cooling surface for both condensers is 10,040 square feet, with tubes ⅝ inch in external diameter. The circulating water for each condenser is supplied by a 14-inch



TRIPLE EXPANSION ENGINES OF H. M. CRUISERS PIQUE, RAINBOW AND RETRIBUTION, CONSTRUCTED BY PALMER'S SHIP BUILDING AND IRON COMPANY, LIMITED, JARROW-ON-TYNE.



TRIPLE EXPANSION ENGINES OF H. M. CRUISERS PIQUE, RAINBOW AND RETRIBUTION, BUILT BY PALMER'S SHIP BUILDING AND IRON COMPANY, JARROW-ON-TYNE.



TRIPLE EXPANSION ENGINES OF H. M. CRUISERS PIQUE, RAINBOW AND RETRIBUTION, CONSTRUCTED BY PALMER'S SHIP BUILDING AND IRON COMPANY, LIMITED, JARROW-ON-TYNE.

Tangye centrifugal pump. There is a cross-connection between these two engine-rooms, so that one pump may supply both condensers in case of accident to the other. Each pump is capable of discharging 750 tons of water per hour from the bilges. The main feed pumps are of the Weir's duplex type, one pair being placed in each engine room. The speed of the pump is controlled by a float in the feed tank. A double cylinder pump of Admiralty pattern is placed in each engine-room for fire and bilge purposes. In each engine-room there are also a Normandy's evaporator and condenser, air-compressing engines, and reservoirs, by Belliss, and electric light engine and dynamo by Willans and Robinson. A separate auxiliary condenser, provided with its own air and circulating pumps, is fitted in each engine-room for condensing the steam used by all the auxiliary engines throughout the ship. The combined surface of the two condensers is 1000 square feet. The positions of the various auxiliary engines have been carefully chosen, and the general arrangement of these and the main engines is such that there is unusally ample room to get easily and comfortably about.

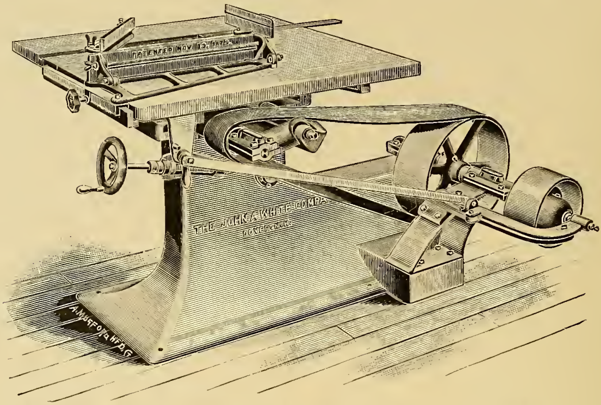
The propeller shafting is of steel throughout, and hollow, the diameters being 12¾ inches and 14½ inches. The propellers are of Admiralty gun-metal, with three blades on each. They are about 13 feet in diameter and 17 feet 6 inches pitch.

There are five return tube boilers, occupying two separate water-tight compartments. Three of the boilers are double-ended 13 feet in diameter by 18 feet 6 inches long, and two are single-ended 13 feet in diameter by 9 feet 6 inches long, the working pressure in all cases being 155 pounds per square inch. There are in all twenty-four corrugated furnaces, each having a separate combustion chamber. The total heating surface is 15,704 square feet, and the total fire grate surface 588 square feet. The boilers are arranged for working under forced draught on the closed stokehold system, the air being supplied by eight double-breasted fans, made by Messrs. Paul & Co., Dumbarton. In the boiler-rooms there are placed for auxiliary purposes, three double cylinder feed pumps of Admiralty pattern, one of them being especially for one of the single-ended boilers, which is intended to be used for auxiliary purposes when in harbor. Provision is made in the double-bottom under the boilers for the storage of a large supply of fresh water, and connections are made from the auxiliary feed pumps to these tanks. The steam from the after boilers and from the forward boilers is led to the engine-rooms by two independent lines of pipes, so that in the event of one of the boiler-rooms being flooded, or its steam pipes damaged, the steam can be taken from the remaining boiler-room to both sets of engines. The main steam pipes are lapped with copper wire as an additional security. In addition to the various engines already mentioned, there are ash hoists; drain tank engines, steering engines, and capstan engines. A workshop is also fitted up with several machines, and a special engine to drive them.

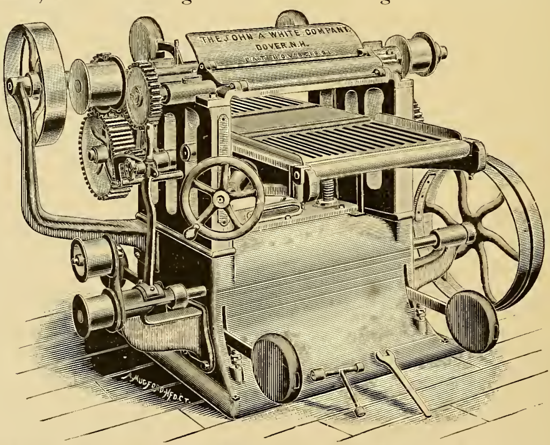
The builders undertook to develop 7000 indicated horse-power, with an air pressure in the stokehold not more than ½ inch, for eight consecutive hours, and 9000 indicated horse-power with not more than 1¼ inches for four consecutive hours. All of the vessels have been successfully tried and the horse-power developed was more in each case than called for in the contract. We are indebted to Engineering of London for the description and illustrations of these engines.

SOME NEW WOOD-WORKING TOOLS.

The band saw shown in the accompanying illustration has been recently placed upon the market by the John A. White Company, of Dover, N. H., and has some novel features. Instead of the usual "tight and loose" pulleys, a combined driving pulley and friction clutch is used, the controlling handle being just to the right of the table, as the operator faces the machine. Both wheels are fitted on a taper, and have ash rims, steel spokes, and malleable iron shoes. The hubs are of a new pattern, with two concentric flanges, the outer bored and the inner tapped to receive the spokes, thus giving them a doubly rigid support. All the usual adjustments may be made while the machine is in operation, and the guide-rod is counterbalanced by a weight.

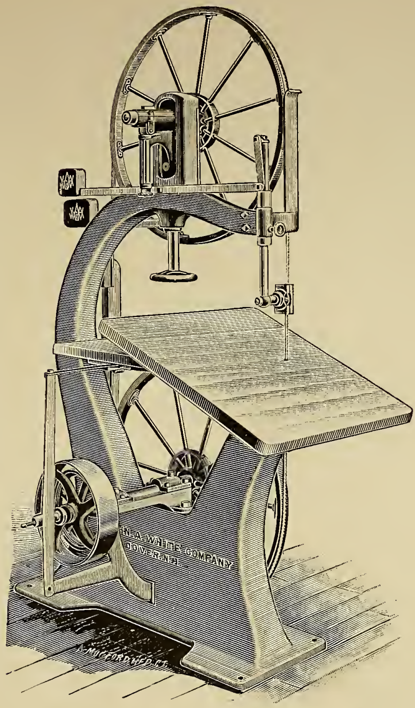


SINGLE SAW BENCH. CONSTRUCTED BY THE JOHN A. WHITE CO., DOVER, N. H.



SINGLE SURFACER OR PLANER. CONSTRUCTED BY THE JOHN A. WHITE CO., DOVER, N. H.

The single saw bench has the same form of clutch driving device, instead of the usual tight and loose pulleys, and has a hand wheel on the front of the machine for raising and lowering the saw arbor, the table being stationary.



THIRTY-SIX-INCH BAND SAW, BUILT BY THE JOHN A. WHITE COMPANY, DOVER, N. H.

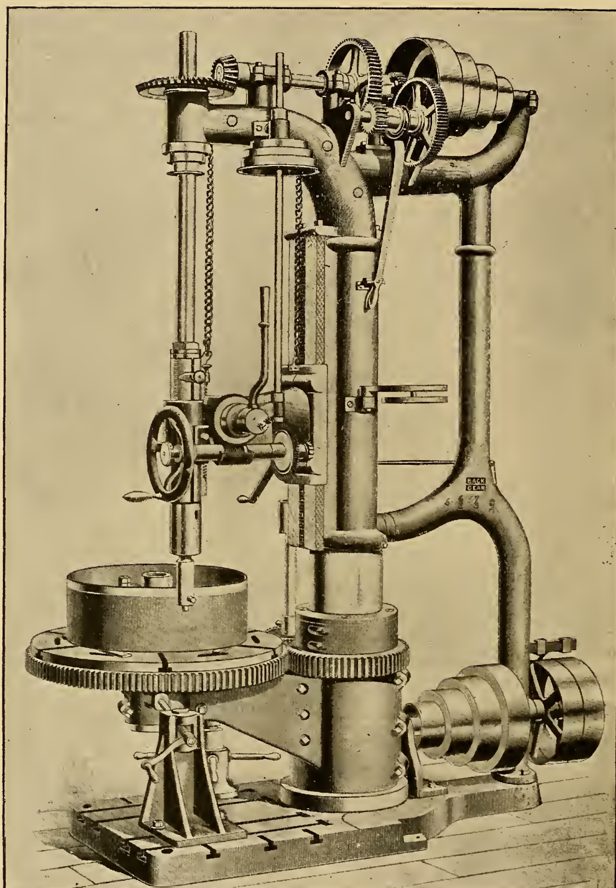
The entire left hand portion, however, is arranged to slide on guides away from the saw, leaving ample space for removal, adjustment of special heads, etc., etc. The table is of iron or wood, and the machine is designed for heavy service.

The "Concord" Single Surfacer, although not strictly a new tool, being already well-known to the wood-working fraternity, has recently been modified and improved. As now designed, the cylinder boxes are nine inches long, lined with genuine Babbitt, the bed guides have been lengthened, and extra material has been added where needed. The illustration shows the 24 inch by 10 inch size.

FORTY-TWO INCH BORING AND DRILLING MACHINE.

The 42-inch boring and drilling machine, of which an illustration is printed on the page following, has been lately very much improved by the builders, the Lodge & Davis Machine Tool Company.

The main point of improvement is in the table driving mechanism, which enables this machine to operate upon a much larger range of work than the old machine. The pinion driving the table revolves around the column and is provided with steel anti-friction rollers and ball bearings, eliminating a large pro-



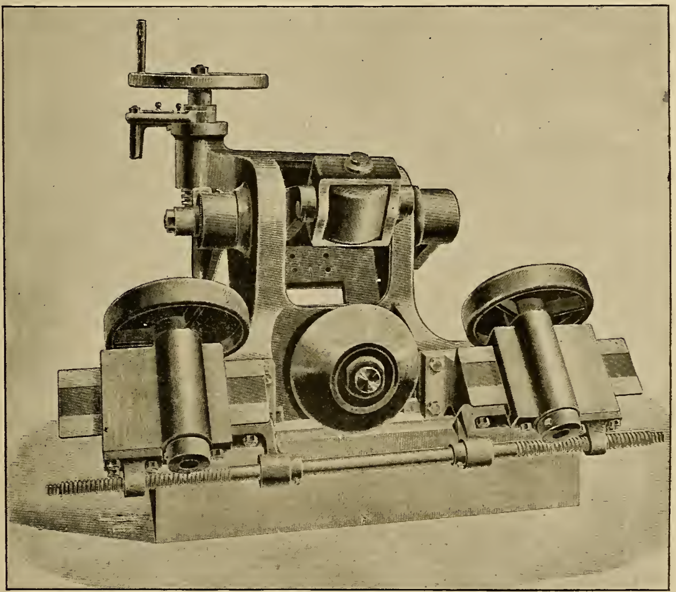
FORTY-TWO-INCH BORING AND DRILLING MACHINE, BUILT BY THE LODGE & DAVIS MACHINE TOOL COMPANY, CINCINNATI, O.

portion of the friction at this point. It will be seen by this construction that the table may be swung out of the centre, and to any position within its radius to accommodate the position of the cutting tool placed in the tapered hole in spindle. Thus pulleys, mill-gearing, car-wheels, sprocket-wheels, and a multitude of such work may be bored and then faced on the outside circumference. The table feed is made by means of screw, shown on side of same. The power feed is operated from the front of the machine, and is furnished with an attachment which automatically stops the feed at any desired point, which may be indicated by a pointer and graduations in the spindle. The driving gears are covered to avoid breakage and accidents to the operator.

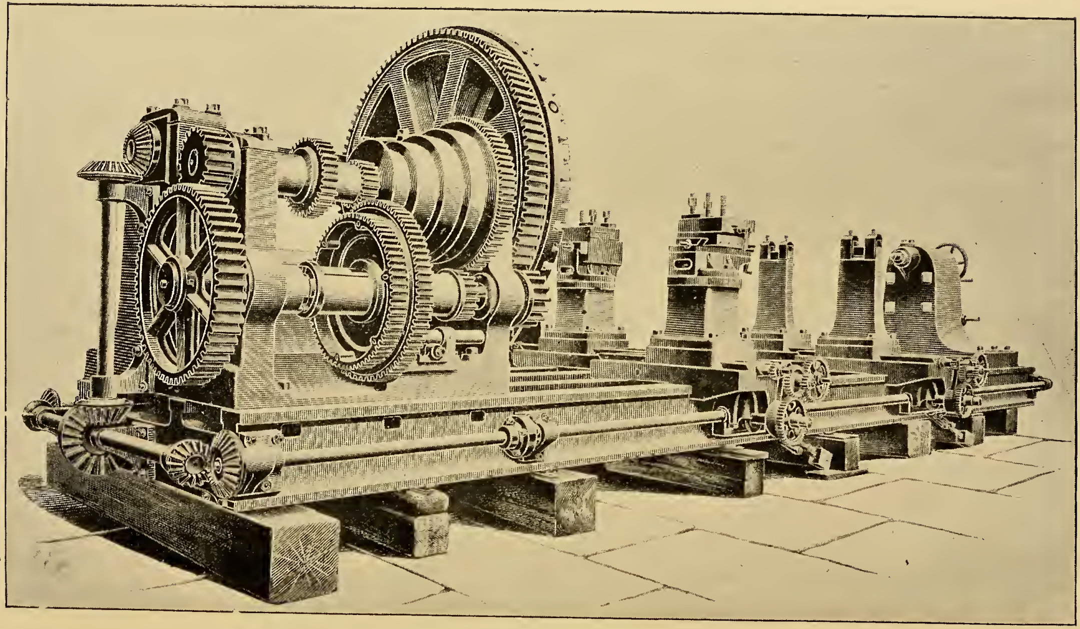
A BOILER FLUE FLANGING MACHINE.

The illustration shown on this page is of a boiler flue flanging machine for spinning the flanges generally used for the ring seam joints of the furnace tubes of Lancashire and Cornish boilers. Although these types of steam generators are not much used in America, a description of the machine may nevertheless be of interest.

The roller runs on a pin fixed in a frame, which swings on two axes placed at right angles to those of the bottom roller. When commencing to flange the roller is brought flat upon the inner side of the flue required to be bent. The pressure is then applied in the usual way, and the flange commences to form itself to the shape of the bottom roller. By this means it is claimed not only that the flange can be formed more correctly, and with less skill, but also that the rim of the flange is better developed and not so liable to give way to grooving at the root, a defect which is not unfrequently met with in steam boilers, and which gives rise to considerable trouble when repairs come to be effected. The improvement described may be applied to any other kind of flanging machine.



BOILER FLUE FLANGING MACHINE, CONSTRUCTED BY MESSRS. BINNS BROS., HALIFAX, ENG.



DUPLEX LATHE FOR MARINE CRANK SHAFTS, CONSTRUCTED BY MESSRS. HULSE & CO., ENGINEERS, MANCHESTER.

Reflections and Observations.

THE writer paid a visit to the Mechanics' Fair in Boston a few days ago and stood for a moment near an engine in the basement. The engineer in charge possessed a bright little son whom he had taught the method of stopping and starting the machine. The little boy, who did not appear to be over ten years of age, was standing by the engine when a gentleman came up to him and said :

"You seem to be a pretty small boy to run such a big engine."

"I suppose I am pretty small," replied the boy, "but I can do it all right."

"You think you understand your business," continued the visitor.

"Yes, sir," I do.

"Can you start the engine?"

"I can."

"Let's see you start it."

The boy opened the valve and the fly-wheel slowly started to revolve.

"You really can do it, can't you," said the visitor.

"Yes, sir," modestly answered the boy.

"Can you make it go backwards," asked the man.

"Backwards or forwards, it doesn't make any difference to me," replied the young engineer.

"Well, let me see you run it backwards."

The boy stopped the engine and quickly reversed it so it ran in the opposite direction.

"Well, I declare, my boy, you seem to understand your business perfectly."

The boy said nothing for a moment, but eyed the stranger suspiciously. Suddenly an idea appeared to strike him and he said, "May I ask what your business is?"

"Why, certainly; I am a minister of the gospel."

"Where do you reside?" asked the boy.

"O, right across the river here in Cambridge."

"Do you understand your business," further questioned the youngster.

"I believe I do," replied the minister good-naturedly.

"Can you repeat the Lord's prayer?"

"Why, certainly."

"Say it for me," requested the boy. The clergyman did so.

"You really do know how, don't you," laughingly said the little engineer.

"Why, of course I do; I repeat it several times a day."

"Well, now, say it backwards; you know I ran the engine backwards for you." The clergyman, after a moment's hesitation, said he could not do it.

"You can't do it," said the little fellow. "Well, you see I understand my business a good deal better than you do yours."

The clergyman appeared to think so and retired.

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MANY readers of this magazine have probably received maps of some new Southern or Western city, with the streets apparently beautifully laid out, but no houses built on the land around them. The speculator as a rule has a pretty good excuse every time when an intending investor visits his "city" in order to lay out a manufacturing plant of some kind. He would indeed be a

poor manager for a land company if he ever found himself unable to give a reason for anything that wasn't according to the advertisements set forth. It remained, however, for a land boomer near Muncie, Ind., to give a real sound reason for having nothing but prairie land to show instead of a completed city. An engine manufacturer went down there and looked around with the view of moving his establishment to the place. Getting into the middle of the "city" with his "guide" and having been a patient listener to the boom stories, he suddenly asked "but why isn't this land built upon?"

"Built upon; why the land for two miles around a circle where I am standing is so valuable that we never intend to build upon it," he replied.

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The question of temperature and the real zero several hundred degrees below our present zero was scientifically explained by a writer in this magazine some months ago. Evidently a young man at one of the technical colleges whose fingers were severely scalded was not aware that while all temperatures eventually equalize themselves when brought in contact, that a little time is necessary for the units of heat to be absorbed by something not quite as warm.

The story is told that an experiment was being made in connection with this theory, and that a large piece of ice had been placed in a kettle of boiling water. Just at that moment the student in question, who arrived late, came into the room as the professor said, "And now, of course, that piece of ice in that water has lowered the temperature———." At that momen they oung student placed his hand in the water containing the ice and said, as he hurriedly drew it out, "By thunder, professor, that ice is hot."

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The other day a negro passing down Liberty street, in New York, was seen to look into the window of the warerooms of Russell & Company, of Massillon, Ohio, in which is exhibited one of their high-speed engines. Suddenly he darted across the street, and acted so peculiarly that the writer said to him, "Anything the matter?"

"Not zackly, boss."

"Well, what makes you act so queer?"

"See that thing ober dere in de window?"

"Yes, I see the engine, what about it?"

"Ingine, is it! You don't kotch me 'nar one ob dem things agin."

"Why not?"

"D'ye spose I wanter git hit in de stumick?"

"Well, how could that engine hit you in the stomach, it isn't going."

"Tain't goin'? De odder wasn't goin', but when I got up right close to de ting it cum around and giv me such a whak in de stumick and broke my face, and I just paid a docte1 fo' dollar and nineteen cents. Yer jest bet I'll keep away. If I see dat ingine as youse call it in a forty-acre lot you jest see me run down by de cow road and jump ober de fence."

The Observer.

FROM A RECENT PHOTO. BY W. K. L. DICKSON.

THOMAS A. EDISON.

CASSIER'S MAGAZINE.

VOL. III. JANUARY, 1893. NO. 15

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Third Paper.

BY one of Fortune's vagaries, Mr. Milton Adams, through whose kindly exertions Edison's situation was procured, himself fell out of employment and was at his former protege's charges for lodging and entertainment, both of which were gladly tendered. Edison's hospitable instincts were based upon Victor Hugo's immortal words :

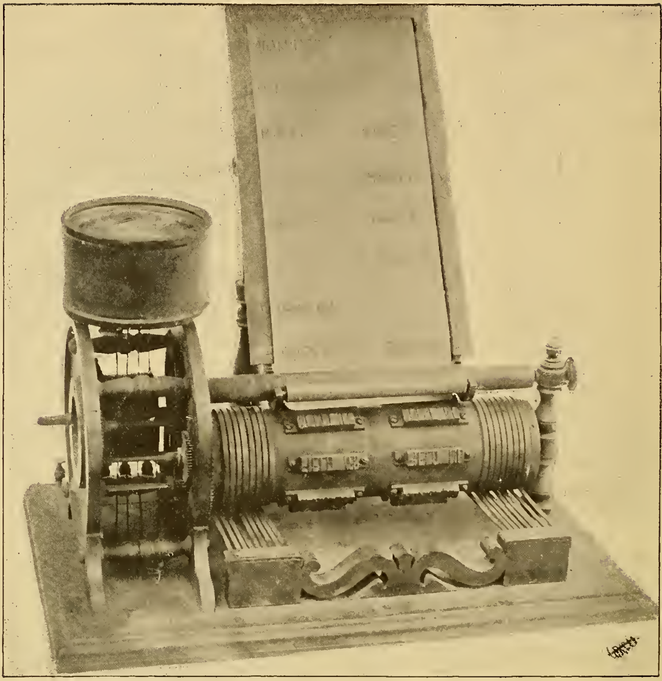
> "Gratitude is a heavy burden; when thou wouldst impose it upon any one, do it only with all the delicacy of which thy soul is capable, so as not to wound him."

We may be certain that Mr. Adams' reverses of fortune and his temporary dependence were made as pleasant to him as circumstances would permit, and that a Mark Tapley humor was born of impecuniosity.

To gentlemen of Bohemian tastes and light pockets, the "Hub" offers many inexpensive dissipations, and of these none commended themselves so entirely to the inclinations of the two friends as lengthened strolls among the second-hand book shops and general junk stores which stud the ungenteel portions of Boston. Here an amusing incident occurred, which we will give in Mr. Edison's own words:

"One day, Milton and I were passing along Tremont Row, when we noticed a crowd collected in front of two dry goods stores and stopped to see what was the matter. It happened that these were rival establishments, and that each had received a consignment of stockings which they were eager to dispose of. Their methods were very entertaining. One would put out a sign stating that this vast commercial emporium had five thousand pairs of stockings to dispose of at the paralyzing price of twelve cents a pair, an announcement which invariably wound up with 'no connection with the firm next door.' In a moment the rival firm would follow suit, underbidding the other by one cent at a time, until the price was reduced to one cent for five pairs of stockings. The crowd had been steadily increasing all the time, contenting itself with jeering and making merry, but showing no avidity to avail themselves of these tempting bargains. Milton and I had been agog, however, for some time, and he now broke out: 'Say, Edison, I can stand this no longer, give me a cent,' and being supplied with this handsome financial basis, boldly entered the store, which was filled with lady clerks. Throwing down the cent, he demanded five pairs of stockings, while the crowd

* Began in November issue.



VOTE RECORDER—THE FIRST INVENTION PATENTED BY EDISON.

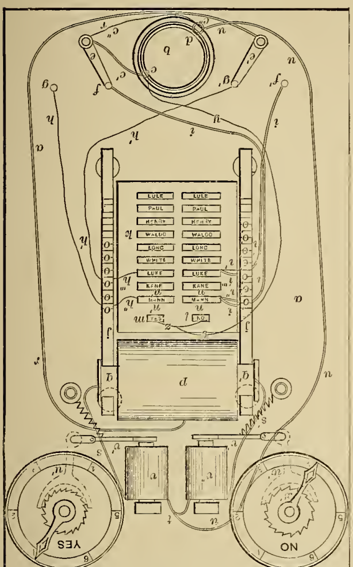
excitedly awaited the result. The young lady attendant surveyed the customer with magnificent disdain, and handed him five pairs of baby stockings. 'Oh!' said my friend, in much discomfiture, 'I can't use these.'

"'Can't help it, young man,' was the curt reply; 'we don't permit selections at that price.'"

The crowd roared, and the commercial struggle ended. All of Edison's investigations were not as fruitless as the above. The queer old shops hidden away in the dusky and gabled streets, yielded up many of those scientific appurtenances without which Edison's life would have been an arid desert. Gradually the workshop, laboratory and library took shape about him and the great city assumed the elements of home. Boston had many features suited to the varied mentality of the young scientist. The northern portion of the city with its quaint architecture and circuitous streets, recalled the historic events of past centuries, and imbued with fresh vitality many a half forgotten legend of his childhood, while Boston of the present, with its converging nationalities, its teeming enterprise, and its exceptional culture, was eminently attractive to his alert and vigorous mind, poised as that mind was upon the pivotal point of receptivity. But dearer than past or present was the future of his country, and the genius of scientific progress exercised paramount sway, inciting to fresh research and ripened effort. The superb resources of the Boston Public Library—a unique

collection of some two hundred and eighty thousand volumes—were at his disposal, bringing him into contact with the master minds of the age, and stimulating into being his dawning inventive powers.

No jealous detraction awaited him at the hand of his employers, and the shallow prejudices of his associates had long since been overcome. The way,



PATENT OFFICE DIAGRAM OF VOTE RECORDER.

therefore, to successful research lay clearly mapped out before him and was unflinchingly pursued.

"I was soon deeply immersed in experimenting," says Mr. Edison, "despite the fact that my rooms in Harrison avenue were a mile distant from the place in Hanover street where I took my meals. I bought, one day, the whole of Faraday's works on electricity, brought them home at three o'clock in the morning and read assiduously until Adams rose, when we made for Hanover street to secure breakfast. My brain was on fire with what I had read, and I suddenly remarked to my friend:

"'Adams, I've got so much to do, and life is so short that I am going to hustle.' And with that I started on a dead run for my breakfast."

During his night work Edison became acquainted with one of the mechanics in the telegraphic instrument factory of Charles Williams, Jr. This workman was "addicted" to experimenting, and joined Edison in many of his exploits, one of which was very nearly the means of bringing the scientists to an untimely end.

"I had read," says Mr. Edison, "in a scientific paper the method of making nitro-glycerine, and was so fired by the wonderful properties it was said to possess, that I determined, with the help of the above individual, to make some of the compound. We tested what we considered a very small quantity, but this produced such terrific and unexpected results that we became alarmed, the fact dawning upon us that we had a very large white elephant in our possession. At six A. M. I put the explosive into a sarsaparilla bottle, tied a string to it, wrapped it in a paper and gently let it down into the sewer, corner of State and Washington streets."

Shortly after Edison's arrival in Boston he commenced experiments upon a vote recorder, exclusive rights for which were obtained in 1869. This was Mr. Edison's first patent, and might be simply described as an electrical apparatus for recording votes. By turning one of the switches placed at each voter's desk, either to the right or to the left, the current from a battery flows first through a magnet, actuating an armature, impelling forward a ratchet wheel, to which a pointer is attached, and so registering one vote, affirmative or negative, as the case may be. The same current simultaneously releases a clockwork movement which turns two metal rollers, the upper smooth and working on an eccentric, by a rising and falling movement, the lower embossed with a double set of types (as shown), between which a sheet of chemical paper is carried, the current

passing to the upper roller through the paper to the raised type. This completes the circuit, leaving a brown impression or stain. The printed record passes up and down in full view, exhibiting the votes for and against the several candidates or bill under consideration.

The fruition of this ingenious device had been a labor of love with the young inventor, who spared neither time nor money to secure its introduction. Through the zealous efforts of Edison's friends the matter was brought before the Massachusetts Legislature, but unsuccessfully, and for a reason which furnishes a significant comment upon our political methods.

"No use, Edison," reported that gentleman's plenipotentiary on his return, "the thing is a dead failure."

"Impossible," replied the young inventor aghast, "I know it will work."

"Yes," answered his friend, "for that very reason it is a failure. I talked with some of the members and they explained to me how the great power of the House lies in their being able to employ obstructive tactics, called in parliamentary language *filibustering*, and indulged in for the purpose of preventing partisan legislation. This invention of yours would take away that power, and they would not have it in the House if you paid them to use it."

"Ever after," says Mr. Edison, "I investigated minutely the necessity of any particular invention, before I attempted its reduction to practice. To this decision I have made it the rule of my life to adhere."

After completing the vote recorder, Edison's next move was the enlargement of a small workshop used habitually by him for his private experimenting. There he labored during the hours of daylight, building mechanical appliances, and erecting lines for different firms, utilizing dial instruments of his own manufacture. This in connection with his regular night work at the Western Union Telegraph Company. During this time he conceived and partially matured a stock quotation printer, for printing the price of stocks in various broker's offices, erected several lines and put in a number of instruments, but meeting with inadequate encouragement on this score, he abandoned the scheme for the nonce and applied himself to the development of duplex telegraphy. It will be seen later in the episode relating to Edison's arrival at the headquarters of the Laws' Gold Reporting office, how excellent and opportune was the information garnered during this seemingly fruitless epoch.

Edison's scientific position in Boston was now firmly established, and his moral status so unimpeachable that he was selected by a fashionable female academy to lecture on telegraphy. Immersed in other projects, he not only neglected to inquire into the sex of his audience, but totally overlooked the appointment, and when summoned by his friend, Mr. Adams, was discovered on the top of a house performing certain acrobatic feats connected with the erection of a telegraph wire. Curiously enough, Adams shared his colleague's ignorance in regard to the expected ordeal and possessed like Edison with the belief that the audience would be composed of boys, thought it unnecessary, in view of the advanced hour, to devote any time to personal adornment. Unsuspiciously they hurried through the streets and plunged into the scientific arena, where to their horror and amazement they found themselves confronted, not by a horde of undisciplined boys, but by an assembly of elegantly attired young ladies. Confusion descended on them, their tongues clove to the roofs of their mouths, and the upturned sea of quizzical faces before them loomed faintly through a crimson haze. At last, Edison, possessed by the courage of despair, and seeing that Adams was absolutely *hors de combat*, plunged into the exposition of his subject and succeeded, in spite of certain catching sensations at the back of the throat, in conveying to the fair scientists a brief, pleasant and lucid view of the subject.

To the credit of incipient womanhood be it chronicled, that this diffidence served Edison's cause better than

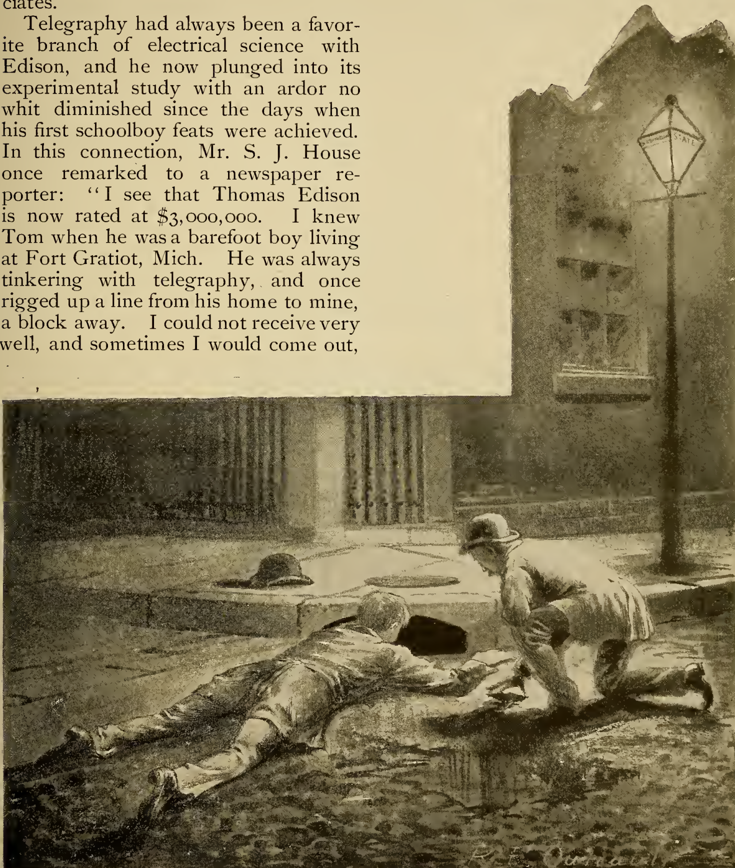
a bumptious and self-satisfied glibness would have done.

> "In the modesty of fearful duty
> They read as much as from the rattling
> tongue of saucy and audacious eloquence."

From that day the sweet girl graduates made a point of recognizing Edison in public, and bestowing upon him such nods, becks and wreathed smiles as made him a subject for envious admiration among his less favored associates.

Telegraphy had always been a favorite branch of electrical science with Edison, and he now plunged into its experimental study with an ardor no whit diminished since the days when his first schoolboy feats were achieved. In this connection, Mr. S. J. House once remarked to a newspaper reporter: "I see that Thomas Edison is now rated at $3,000,000. I knew Tom when he was a barefoot boy living at Fort Gratiot, Mich. He was always tinkering with telegraphy, and once rigged up a line from his home to mine, a block away. I could not receive very well, and sometimes I would come out, climb on the fence and holloa over to know what he said. That always angered him ; he seemed to take it as a reflection upon his telegraph line."

Telegraphy had made very little perceptible progress during the period of Edison's investigations. It was in 1832 that Prof. Morse conceived the idea of an electric telegraph, the practical exposition of which was afforded in 1837, when he constructed his first working apparatus, consisting of a small wooden



"I PUT THE NITRO-GLYCERINE IN A SARSPARILLA BOTTLE AND CAREFULLY LOWERED IT INTO THE SEWER."
SEE PAGE 165.

base, on which an electro-magnet was mounted, over which an armature or piece of soft iron was pivotally swung. At one end of the armature a steel point projected, under which a sheet of paper, attached to a groove cylinder, was made to revolve, by clock work, at uniform speed.

The electro-magnet, made as now—of a core of soft iron, surrounded by many turns of insulated wire—when put into action by the distant closing of a key, caused the armature to be attracted as long as the current was allowed to flow through the magnet, the key being meanwhile held down. The result was a series of long or short dashes—impressions made at the will of the operator upon a traveling roll of paper. A pen was substituted later by Prof. Morse in place of the steel pointer, together with a long strip of paper for the inscription of the dots and dashes. Excellent and indispensable as was the basis afforded by the Morse system, it still presented certain imperfections and limitations, and to the removal of these Edison applied himself. His more matured experiments, commencing in 1869 and extending over a period of some six years, were crowned by a system of telegraphy, combining in such an eminent degree the attributes of inexpensiveness, ease of manipulation and increased speed, that to this day, despite furious litigation and envious detraction, it holds its own above all competitors. The forms of telegraphy which were eventually evolved from this source are too numerous to mention, and the underlying details too complicated for full explanation in a work of the present kind, but a brief survey of the field may be admissible.

THE ORIGINAL EARLY GOLD AND STOCK PRINTER. PATENTED BY EDISON.

Among the more prominent forms are the duplex and quadruplex, by which two and four messages are susceptible of simultaneous transmission over a single wire. The latter, which is universally held to be Edison's crowning product in telegraphy, has effected in America alone the enormous saving of $15,000,000 by the use of this single wire for the two and four wires hitherto employed.

Nor does Mr. Edison propose to rest upon these results. He has been, and still is, engaged in experiments which bid fair to extend the quadruplex system into a sextuplex or even an octuplex, admitting of the passage of six and eight simultaneous messages over the same wire. This is tantamount to the facilities afforded by 70,000 miles of wire, in addition to those already in use by the Western Union Telegraph Co.

Two of the main features of the quadruplex system are probably based on the discovery of the polarized or neutral relay, and the earlier discovery in 1872 that simultaneous transmission in opposite directions over a long line may be made feasible by the use of a condenser.

In order to understand in a measure how more than one message can be sent over a single wire, it must be clearly borne in mind that two methods are adopted for the transmission of these messages, which are totally different from each other. One method is commonly known as the *double current*

system, and the other as the *single current* or *open circuit system*.

The double current system simply means that both negative and positive impulses are sent over the line to a distant relay without breaking the circuit at the key, which is provided with a double spring contact, and does not release the positive contact before making connection with the negative one. Thus the current on the line is instantly reversed at the beginning and end of each upward and downward stroke of the key, the circuit being always closed.

THE EDISON UNIVERSAL STOCK PRINTER.

The receiving relay has a permanently magnetized armature, and is free and without checking springs, being solely dependent for its action upon the reversals of current in the line, rather than on the strength of the latter.

In the open circuit or single current method, the relay is entirely dependent on the increase or decrease of a given current, which acts also on a polarized relay, having for an armature a permanent magnet, or even a core, composed of soft iron, controlled by a spring.

Strength of current in the one instance and polarity in the other are the distinguishing features of this method, and when these are used in connection with the duplex principle of dual messages, simultaneously transmitted over the same wire, the feasibility of quadrupling the number of these messages will be at once apprehended, and it will be unnecessary to explain the tangle of wires, magnets, condensers, quadruplex instruments, double and single transmitters, polarized relays, and to follow the various circuits, before the messages are allowed to escape upon the line.

Science no longer springs, full panoplied, from Titanic brains. Many hours of thought travail were needed to develop the immature ideas connected with the several branches of telegraphy, and their entrance into the scientific world was attended by distrust and detraction. In 1869, a year which wit-

nessed the termination of Edison's Boston engagement, the duplex system was sufficiently matured to admit of a trial experiment, which was performed with the co-operation of Mr. F. L. Pope, patent adviser of the Western Union Telegraph Company. Imperfect as were the results, they yet presented to Edison's prophetic mind the germs of future greatness, and inspired him with the desire of prosecuting his schemes in a wider field of action. A daring contemporary writer has observed "great is the Hub, but when a genius outgrows it, he goes to New York," and to New York our adventurer betook himself, after a flying trip to Rochester, undertaken for the purpose of testing the principles of his new invention by the wires of the Pacific and Atlantic Telegraph Company, but from the failure of the assistant at the New York end to understand the adjustments of so complicated an apparatus, the experiment was fruitless.

Not only was Edison's arrival in New York attended by his chronic condition of impecuniosity, but by a painful load of debt, amounting to some two or three hundred dollars.

Three weeks of picturesque nomadism followed, during which the lad suffered many things from hunger, rough quarters and discouraging interviews. One day, just at the time when courage and physical endurance were at their lowest ebb, he found himself on the steps of The Laws' Gold Reporting Company's office, Wall street. This establishment was the focussing point of no less than six hundred broker offices, to each of which it was connected by a system of indicators, and upon the successful working of these were based the pregnant issues of commercial activity. If the great heart of this gigantic system showed the faintest deviation from its accustomed rhythmic beat, it was the pleasing habit of these brokers to stimulate its action by the instantaneous despatch of a small boy, charged to the brim with excitement and indignation.

At the period of which we write, the Wall street world was convulsed to its centre, and every interest, social or political, was subordinated to the frenzied scrutiny of the financial field. Black Friday, that momentous struggle of September 24, 1869, instigated by Jay Gould and his peers, was already presaged in the frenzied excitement, the growing cunning and cupidity of the day. The brokers had been charged by the confederated schemers, Jay Gould and James Fisk, Jr., to buy up all the gold within the bounds of New York city, with a view to creating a corner in the gold market. Steadily the price of gold rose, the speculators designing to carry it from 144 to 200 at least. The financial situation culminated on the twenty-fourth of September; the banks were rapidly selling, and gold was quoted at 162½ and upwards; many business houses were on the point of closing, from ignorance as to the prices charged for their goods. The terrible tension was brought to an end by the announcement that Secretary Boutwell of the United States Treasury had thrown $4,000,000 of the precious metal on the market! Gold at once fell, and Messrs. Gould and Fisk retired from the field winners to the amount of many millions, but many reputable firms were ruined. Events so black with portent could not but cast evil shadows before, and for many preceding days and weeks the air was heavy with prophetic gloom. Hearts had broken beneath the strain; lives were wrecked; fortunes vibrated on a pivotal centre more precarious than that of Karnac's sacrificial altars. Inflamed by the lust of gold, and reduced to the semblance of insatiate brutes, the great sea of sentient humanity surged around the shrine of its desires, screaming, cursing, gesticulating and fighting, filling the air with cruel shouts of triumph, or senile bursts of weeping—a scene inexpressibly base and humiliating, and which supplied no suggestion of that "measure of a man which is an angel."[1] Alas!

> "How quickly Nature
> Falls to revolt when gold becomes her object."

At the supreme moment of this ignoble excitement, and while the eyes of

thousands were riveted on the statistics supplied by the hundreds of indicators, the stock quotation printer, in the central office, suddenly collapsed, and with it expired every subordinate source of information. Everything moves quickly in Wall street, and within the space of a minute the various avenues leading to the main office were thronged with the entire force of boyish emissaries—six hundred or more—each supplying his quota to the turmoil, and putting the finishing touches to the acute misery of the manager, who could not discover the cause of the trouble.

George Laws, of Laws' Gold Reporting Company, was a gentleman of keen susceptibilities and exuberant emotions, with a nervous system poised delicately on a hair trigger. His superintendent, Mr. Frank Pope, resembled his chief closely in these respects, and in sudden emergencies the two men acted and reacted upon each other in a manner calculated to neutralize stagnation, but scarcely to promote the even tenor of commercial ways. This sudden and inexplicable calamity threw Messrs. Laws and Pope completely off their mental balance, and, to use a stage expression, they were adjuring the heavens, the nether regions and each other for assistance, waving the six hundred frantically aside, and exhibiting generally the features of advanced dementia.

It was at the moment that Edison, without any apparent reason, found himself among the crowd surging against the door.

HOW EDISON AVERTED A PANIC IN THE GOLD MARKET.

Under cover of the pervading confusion, Edison had passed in unnoticed, subjected the apparatus to a swift but thorough scrutiny, and then quietly remarked: "I think, Mr. Laws, I can show you where the trouble lies. There is a contact spring which has broken and fallen between two cogwheels, and prevents the gear from moving."

This proved to be the case. The obstruction was quickly removed, and the vital centre was again in touch with its dependent organs. Mr. Laws' emotions, now directed into pleasurable channels, overflowed upon this mysterious messenger of the great god Plutus, whose timely arrival had so revolutionized affairs, and Edison soon found himself the centre of admiration and the focusing point of hero-worship to the six hundred. A brief conversation ensued, a few unimportant inquiries were made, and the whilome vagabond, with his floating establishment, his frayed garments and his dirty shoes, soon found himself in the enviable position of confidential advisor to an influential firm, with the prospect of certain and remunerative employment. These negotiations were concluded on the following day, when Edison was requested to call again at Mr. Laws' office. At that interview he was asked many additional questions, the answer to which indicated such a thorough familiarity with the apparatus that Mr. Laws, foreseeing a respite from the vicissitudes which were threatening to undermine his constitution, finally inquired whether Edison could take charge of the whole vast machinery and pledge himself to run it successfully. Edison quietly replied in the affirmative, whereupon Mr. Laws at once engaged him at a salary of three hundred dollars per month, very nearly three times as large as Edison had ever been in the habit of receiving as an operator.

Relieved from the pressure of financial embarrassment and stimulated by the confidence displayed by his new employer, Edison brought many of those ideas into requisition which his lack of means and influence had forced him to abandon. The Gold Indicator was placed in his charge and interwoven with important improvements, but this was eventually abandoned for a stock quotation printer of Edison's own devising, the workings of which were so satisfactory that Mr. Laws spared neither trouble nor expense in introducing it. The Edison stock printer was at that time intended principally for the gold market, and was designed to print letters, figures or characters from a double type wheel.

The current flowing through two electro-magnets, placed side by side in the receiving instrument, operated a type wheel, which in its turn, after an almost imperceptible pause, in which the wheel is allowed to rest, passes on to the second magnet, which furnishes the impelling power to the printing mechanism.

The operation of these magnets is controlled by a clever arrangement of escapements and gears, the sending and receiving instruments working exactly together, so that the band of paper is brought up suddenly against the type wheel by a wave of passing electricity. Each electrical impulse carries the paper on one step, and the rotating wheel being brought into contact with a felt roller, saturated with printer's ink, the desired impressions are produced.

The success of the new instrument so alarmed competitors that a consolidation took place and Edison lost his position. He was, however, soon offered one by the consolidated company, which he refused, preferring to enter into a copartnership with a firm of electricians. While connected with this firm he invented an improved form of the gold and reporting printer, and a prosperous exchange was established, which was ultimately bought up by the consolidated company.

(*To be continued.*)

THREE MILLION HORSE-POWER IN WINTER.

By Robert Grimshaw, M. E.

THERE is a best time to see everything. The Wizard of the North said :

> "If thou wouldst view fair Melrose aright,
> Go visit it by the pale moonlight."

or words to that effect.

Bushkill Falls in the spring, Starucca Valley in the fall, Niagara in winter. At no time can the human mind, however artistic or poetical in its make-up, fully appreciate the grandeur alone, or the beauty alone, of this wonderful natural curiosity; nor is there any time at which the engineer, however trained to measure or to estimate power, can fully comprehend that over this precipice is falling a mass of water capable of developing a power which Sir William Siemens states to be the equal of all the steam-power in the world.

For one to appreciate Niagara—by all odds the "show place" of the world—one must see it in every season, and approach it from every point of view, that its wondrous beauty, grandeur and force may in some slight degree penetrate the intellect and work upon the sensibilities. Almost everyone who sees it in summer, sees it in summer only ; but while it is well to see it then, if one can see it at no other time, yet if there is choice of time at which to see it only once, that time should be when the huge volumes of water which roll incessantly over its mighty cliff are made more impressive by blocks of ice plunging over into the abyss, and are framed in an all-whitened landscape, while below the mist which rises from the furious boiling cauldron is, as it were, petrified in monumental glory.

As architecture is said to be frozen music, and all the more forcible as a means of expressing beauty because its effects are produced in a solid and tangible medium, so the waterfall, when supplemented by cascades of what was mist, but is now held high in air, is all the more impressive because the eye may rest thereon and dwell on its mass and form without being led away by the sense of motion. No fairy grotto, no iceberg, no glacier, can produce the effect of the Falls when all below them has taken on its wintry garb ; for the glacier gives only the sense of vastness without motion, while Niagara in winter has all the thunder and motion of its summer state, plus, as a contrast, the suddenly arrested matter which hangs high in air, glowing with the prismatic hues in even greater variety and even greater extent than does the summer mist—with this additional advantage, that the play of colors may be seen from every point of the compass ; and at night the electric light may be brought into service to give it an entirely new and magic aspect, and produce an effect that may be imitated nowhere else on the globe.

But while the poet might rave over the suggestions, the artist go into raptures over the beauties, the orator glow with fervor and discourse with winning eloquence concerning the associations of this wonderful and inimitable sight, the engineer is limited to plain statements of facts which he may not vary, and figures which he may not change ; while the limitations of the human intellect prevent him—as any one—from fully comprehending their amount. No finite mind can really comprehend what "a million" implies ; and whether it

NEAR PROSPECT POINT.

be one million or ten million is practically all one unless considered as divisible, and each part taken by itself.

Three million horse-power! This volume of water, which has been raised from the surface of the land by the sun's heat, practically as steam at atmospheric pressure, is condensed by chill air currents over a large area of country; flows by gravity to where it can attain the lowest level, and in falling, obedient to the immutable laws of nature, is practically the greatest low-pressure condensing engine in the world. It would take the consumption of 15,000,000 tons of coal per year to do the same work which has been done by the heat of the sun in raising the vapor of this mass of water to such a height and letting it fall to its original level. Every minute there is done an amount of work equivalent to the raising of 750,000,000 tons of water from the lower level to the upper, to fall thereto again.

Of this stupendous amount of power, the small fraction of 100,000 horse-power—something more than three per cent.—is to be utilized in doing man's work. About nine years have been spent in getting ready since the inception of the plan by the present company. A canal nearly one-third of a mile has been cut at right angles to the mighty river; a vertical shaft 140 feet deep—as deep as the average church steeple is high—has been sunk; from its lower level a tunnel twenty-eight feet high and eighteen wide, and nearly one and one-third miles long, has been run, falling nearly fifty feet in that length, to deliver at the foot of the cliffs below the falls, just under the Suspension Bridge which at one time was considered such a wonderful piece of engineering. Soon, the neighboring mills and factories of the city of Niagara Falls are to be run, and its street-railway cars propelled, by a trifling fraction of this trifling fraction of the cataract's entire power. New factories are going up, to be ready for

THE HORSE SHOE FALLS.

the power when it is ready—which will be before the World's Fair has been opened. Thirty acres of land have been reclaimed from the river, which has been deepened in front of the new wharves. The three principal lines of railway which pass through this new manufacturing centre are to be connected by a five mile railway passing through the land of the company which is putting the Falls in harness ; on this railway there are to be used electric locomotives—worked, by the way, by acquired the exclusive right to use all electricity generated at the new tunnel, for distribution in that city, and the local coal trade will suffer by the lessening coal consumption, but the country at large will be benefited. The ultimate result may be to have 1,000,000 people in Buffalo very early in the twentieth century.

Local interests are not slow in taking advantage of the new régime. The Niagara Falls Paper Company is one of the many concerns which will draw

THE CANADIAN SIDE.

the alternating current which was so frowned on a few years ago; "the stone which was rejected by the builders has become the chief corner stone." Stupendous turbines of 5000 horse-power each are being built to drive the mammoth dynamos from which the high-pressure currents are to be taken to where men want them.

As the result of these improvements, effected and to be effected, Buffalo is again looming up as a manufacturing and shipping centre. A company has

from the canal—its head race of 500 feet long, 46 wide, 12 deep, supplying the power foı an immense business.

The ideas of those who long ago saw that Niagara gave the greatest opportunity in the world for a power station, was to distribute power by water pressure—thus involving a central pumping station, a series of distributing mains and suitable working motors, and the advocates of this system even now point to the anomalous condition of affairs at Geneva, where the electric

station, which is built right on the river, is driven by pumped-up water, which is returned from the reservoir outside of the city.

But I wander. The engineering possibilities at Niagara impress themselves on my mind, whether in summer or in winter, and even when all about is most beautiful, as now, with stalactites weighing tons dropping from the cliffs and stalagmites like young hills reaching up to meet them, with foam frozen as into marble, with every rock encrusted with ice, with the thickly-clad visitors crossing and recrossing on the great ice bridge (which is now firmer than ever before for many years), with the swirling of the mighty waters, the thundering of the echoes that they raise, the mad antics of the great ice-cakes as they gyrate through the rapids, or float on seaward, carried by a current against which it would be in vain to protest, with the rainbow broken up and displayed on every hand, with the burning sun shining without effect on the giant snow fields and ice floes, with the frosty air nipping the features, with the fretted

THE ICE BRIDGE UNDER THE FALLS.

THE AMERICAN FALLS.

waters below the falls assuming myriad and ever changing patterns, while I hold my breath without knowing why—through all this there comes, in winter as in summer, this thought :

Three million horse-power !

"BLACK-PRINTS."

THE prejudice which attached to the earlier processes of producing drawings in black lines on a white ground, by sun-printing from tracings, is now disappearing, by reason of the introduction of the "gallate of iron" black-print process, invented by Poitevin, as an improvement on or substitute for Sir John Herschel's blue-print process, and the "blue-on white" process. By it there are obtained copies which are laterally unreversed, as in the white or blue-prints, but which are not reversed as to shades as in the latter, while not requiring as many developing, toning, and fixing baths as the blue on white process. The bichromate of potash process gives lines which are nominally black on white, but which are really greenish black on a greenish white ground ; and the paper must be prepared at the time of printing, in which respect the process is inferior to blue printing. The gallate of iron process gives lines which are at first nearly jet black, on a pure white ground, and which further darken with age to the appearance of lithographic work ; the paper keeps better than most blue-print paper ; the process is simple and rapid, and the prints stand alterations, erasures, and re-drawing upon.—F. P.

THE GOVERNING OF STEAM ENGINES.

By F. M. Rites, M. E.

IT has been thoroughly and repeatedly proven by actual experiment that however well designed a steam engine may be to suit a certain defined set of conditions, its average results over a range of varying conditions may depart indefinitely from its maximum efficiency in proportion to the character and extent of the variations.

Before the present general introduction of electric service, the demands upon the average power plant were practically uniform, or varying in but a moderate degree, while the exception to the rule was comparatively so unusual that it was either ignored or the additional cost of operation considered a legitimate but unfortunate necessity.

Coincident with the prominent appearance of the electric industries, a necessity was experienced for a practical uniformity of service under widely varying loads. More especially is this true in the case of electric railroading, where the fluctuations are continuous, extreme and violent. Indeed, it may be asserted that such service is probably more severe on both the durability of the mechanism and the consumption of fuel than perhaps any other form of power consumption. To what extent this is true, however, is hardly realized even by those most interested, and indeed positive and comparative figures are often difficult to obtain by reason of the different conditions surrounding plants of such a character. As an evidence of its serious nature, we need only note results in a single instance where the conditions were exceptionally favorable for an electric railroad, but whose name and location it is to be regretted are not yet open for publication. The horse-power in this case aggregated several thousand, and the cars operated numbered in hundreds, so that variations in power might reasonably be considered as relatively small in percentage of total amount, and when occasionally extreme, of so seldom occurrence as not to materially affect the general result. Yet these engines, guaranteed to deliver a horse-power on the consumption of 13½ pounds of steam, with every appliance conducive to high economy—such as triple-expansion, steam-jacketing and condensing—actually used on the average of working hours over 21 pounds of steam per horse-power per hour. And yet the builders are prepared to demonstrate a margin above security of their guarantee under constant conditions, and are certainly justified from their wide experience in their conclusions in spite of these figures. However that may be, the question very naturally arises, if 13½ be the best, and 21 the average, what was the worst?

And then another question follows fast. If 21 be all that can be attained under such favorable conditions of electric railroading, what would be the results in a less pretentious plant, or one with a smaller horse-power, fewer cars, more frequent and higher hills, and none of the devices that act to increase the economy of the engines.

However, it is useless to speculate, and the fact only remains that the average cost of operation of this plant under exceptionally favorable conditions for railroad work was over sixty per cent. greater than was possible to obtain under conditions of practical uniformity.

Leaving out of consideration the question of variations of economy due to faulty variations of the distribution corresponding to varying loads, as it has been often and excellently treated, let us confine ourselves to the question

of governing alone and its influence on the economy of the engine.

It has always been a matter of pride among engine builders to produce a governor regulation so excessively fine that extreme variations of load or steam pressure should not materially alter the rate of revolutions, and the conclusive test has been to measure the actual number of revolutions for a given time under the respective conditions of load or steam pressure.

The subject of rapidity of regulation, however, has never had the attention it deserves, and that quality is of far more importance to electric railroading than percentage of variation of speed legitimately due to the degree of regulation of the governor.

At the present stage of development of steam engineering there is no difficulty at all in securing perfect isochronism in almost any governor, and in the exceptions by immaterial mechanical changes even these may be made successful; but, however great care be taken in this respect, it avails nothing if the proper adjustment be not made as readily and rapidly as it is called for by the service. If momentarily the speed vary far beyond the degree of regulation, when the load is still within the rating, it is no advantage that the speed will read just in time, and it is no fault of the fluctuating character of the work that the governor is not able to meet as rapidly the adjustments that are necessary.

Even the variations of speed will not be considered here, however, but only the influence of the governor on the economy and the explanation of the enormous discrepancy in the illustration we have given.

Let it be assumed that while the steam distribution is designed for the best efficiency at a particular load, yet the variations of load shall be provided for in any other necessary distribution in a manner that shall yield the highest efficiency for the momentary condition. That is, let it be granted that the law of maximum efficiency with a particular engine under particular conditions holds true over the whole range of conditions. It is not claimed that this has ever been done and is assumed only for simplicity in the consideration of the governor problem, and even with this assumption there is only one set of conditions of maximum economy, and this statement leads directly to the influence of the governor on the economy of the engine.

If under any change of load the governor has not met the demand for distribution as promptly as it is made, the

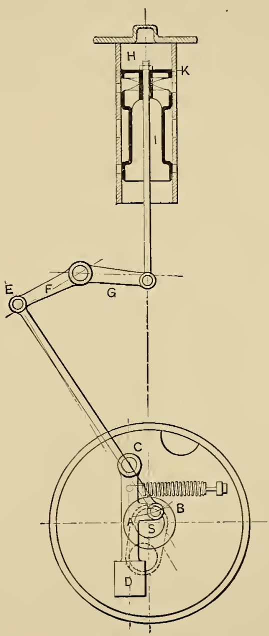


FIG. I.

result is a rate consumption of steam corresponding to some extreme distribution and an average consumption not of the corresponding average condition but the sum of the partial effects, or an average of the consumption corresponding to the distributions actually realized.

Without that perfection of governing when the distribution of steam corre-

sponds exactly to the load and the speed due to that load, there will be a surging on account of the mometum of the parts of the governor greater in extent as the error is more pronounced ; so that it is perfectly possible, if it were so disposed, to adjust a governor to distribute only in extreme positions to suit but moderate variations of load. Of course, the average work done and the average revolutions per minute are maintained exactly for the average load,

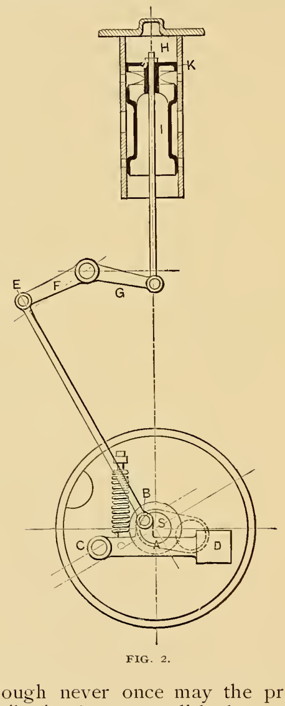


FIG. 2.

although never once may the proper distribution be accomplished.

Without going deeply into mathematics, assume a moderately but practically instantaneously varying load of but say ten per cent. from rated capacity. A purely centrifugal governor (no matter what devices are employed to increase its sensitiveness) must necessarily follow the change of speed for its adjustment. The very nature of the force acting insuring that the mechanism shall, as it were, "hang fire" till the speed had varied sufficiently to generate a positive radial impulse for readjustment, which rapidly growing in amount until readjustment has commenced multiplies its effect until proper distribution has been attained. At this point the momentum of the masses composing the governor have reached their highest velocity of translation and pass to an extreme position until the rate of revolution has been recovered, when the pulsation returns upon itself. Refinement in regulation but increases this effect by removing the restraining influence of the spring's resistance. The only guarantee for a proper performance of such a class of work is a judicious use of the force of inertia, which coincident and proportional to the change of load and speed will not continue its action after the resulting adjustment has been accomplished.

In view of the now generally acknowledged imperative necessity of a governor that can "catch the load" in connection with rapidly and continuously fluctuating loads, it is thought well to here illustrate an example of governor especially designed to meet such service, which incidentally (by reason of the excessive simplicity attained in its reduction to a single mechanical element) should prove particularly interesting. However, notwithstanding the remarkable apparent simplicity, the resolution of forces which conduces to this condition of mechanical simplicity is so intricate that close attention to the following descriptive matter is required in order to thoroughly understand the peculiarities. In general terms, it consists of a single weight only, whose gravity action is balanced in whole or part by the corresponding force upon the valve and its connections, and whose inertia action is designed to be extraordinarily efficient for rapid adjustment.

For greater clearness, the form is shown only in skeleton, although it is complete in number of parts, and for convenience is shown in two positions, best illustrating the action of forces of balance and adjustment.

The engine is necessarily of the vertical type, and in Fig. 1 is shown in the position of nearly at the extreme of the lower stroke, while the valve is in the position of about to open. In the design of this novel form of governor, the distance *A S* from the centre of which the shaft *S* determines the initial

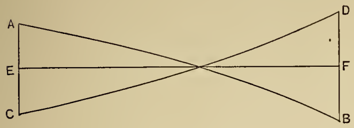


FIG. 3.

tension of the spring, is assumed, as is also the position and path of the eccentric pin *B*. The point *C*, the centre of the movement of the combination, naturally results at the intersection of the lines *A C* and *B C*.

Upon the *opposite* side of the shaft, on the weight arm, and removed as far as the limits of the construction will allow, is located the mass of the governor weight *D*.

Upon the line *S E*, parallel to *B C*, is located the upper end of the eccentric rod, and the valve motion is continued by a rocker *F G* to the valve *I*.

Referring now to Fig. 2, it is evident that a downward pressure, such as the weight of the valve and stem, has a tendency to balance the action of gravity upon the single governor weight, at the same time rendering unnecessary a secondary gravity balancing governor weight, and also another device for independently balancing the weight of the valve gear.

The balancing force transmitted through the rocker is of course continuous, as is indeed the same force upon the governor weight, but both become ineffective at the same time to produce rotation about the pin, while continued revolution of the engine brings them both again into activity, although still opposing and each in an opposite direction to its former moment of rotation.

So far the balancing tendency of gravity upon the weight and valve is plain, but the valve should be much lighter than the governor weight reduced to the radius of *B C*, so that additional downward pressure on the valve will be at least advisable, and is secured by means of a compression chamber *H* above the piston *K*, which, however, in line with the rest of the design, also fills a double bill and acts, in addition, as an inertia balance for the reciprocating parts without additional mechanism.

Referring to Fig. 3, the line of varying pressures is represented by the curve *A B*, so that a varying pressure in the compression chamber *H*, by means of the piston *K*, represented by the curve *C D*, and opposing inertia pressures, would exactly counteract the other, so that the line of results would be represented by the line of neutral pressures *E F*.

If, however, air be admitted into this chamber by means of a check valve, the line of compression pressures rises to a position shown in Fig. 4, and the resultant is represented by the horizontal line *G H*, a certain distance above *E F*, which may be regulated to suit conditions even while the engine is running according to the spring tension of the check valve.

The distance the line *G H* is removed from *E F* then represents constant downward pressure, uninfluenced by inertia of the reciprocating parts and is

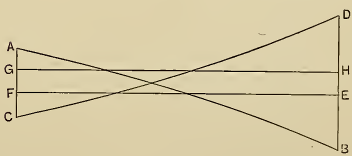


FIG. 4.

to be added to the dead weight of these parts for total downward and uniform pressure.

Particular attention is called to the term *uniform* as applied, for the strain on all the pins of the connections is a uniform one, always in one direction, equal in amount to the pressure ex-

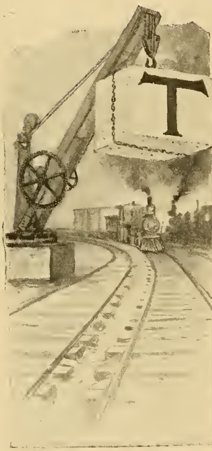
erted while at rest in the position shown in Fig. 2, so that incidentally there has been evolved a single-acting valve gear.

Returning now to the question of efficiency of rapidity of regulation, it will be noted that this single weight, single-acting governor permits an arrangement of mechanical centres of rotation that will utilize its inertia for rapid adjustment to such a degree that would be impossible with the conflicting attachments of the usual double weight mechanism.

Without going into the mathematics of the subject, it is evident that an instantaneous change of speed in either direction results in a corresponding change of relative position of the governor weight, resulting in a change to a suitable cut-off, and it will be impossible to change the load so suddenly but what this design will meet it even over the entire range, for the tendency of the weight to continue its velocity shifts it to a new position, with a proportional speed of adjustment as the time of rotation of the engine shaft is altered.

ELECTRIC TRAVELING CRANES.*

By Anthony Victorin, M. E.



THE accompanying article contains data relative to the performance of an overhead traveling crane at the army gun factory, Watervliet Arsenal, West Troy, N. Y.

The crane is operated by a single (flat-field) electric motor. rent electric cur- The is generated by a Thomson-Houston 65-horse-power dynamo. Its voltage is 500, the speed 1020 R. p. m. The construction of the crane may be seen by reference to engraving. It has a span of 60 feet, a clear hoist of 40 feet, and a capacity of 120 gross tons. The capacity of the auxiliary hoist is 10 tons, hoist 56 feet. The total weight of the whole crane is about 150 tons. The bridge rests on 8 double-flanged wheels (4 on each side) of 36 inches diameter, the trolley on 16 wheels of 24 inches diameter. All wheels are arranged in pairs in compensating beams to avoid inconvenient results from want of uniformity in the level of the track rails. All wheels have also anti-friction steel roller bearings.

The motor *d* is located at one end of the bridge. It receives the electric current through a bare copper wire, *e*, which is strung on insulated rollers along the crane ways. The motor is in permanent gear with the clutch-shaft, *c*. This shaft *c* is fitted with four clutch-gears.

Two square driving shafts, *a* and *b*, are located on the bridge, one on each side. Shaft *a* operates, by means of clutches, the bridge travel and trolley travel and the auxiliary hoist; while shaft *b* operates similarly the main hoist only.

The crane performs the following operations:

Bridge travel=40 and 80 ft. per min.
Trolley " =50 " 100 " "
Main hoist=2, 4, 8 and 16 " "
Auxiliary hoist=20 " 40" "

Automatic brakes are provided to

* Paper read before American Society of Mechanical Engineers.

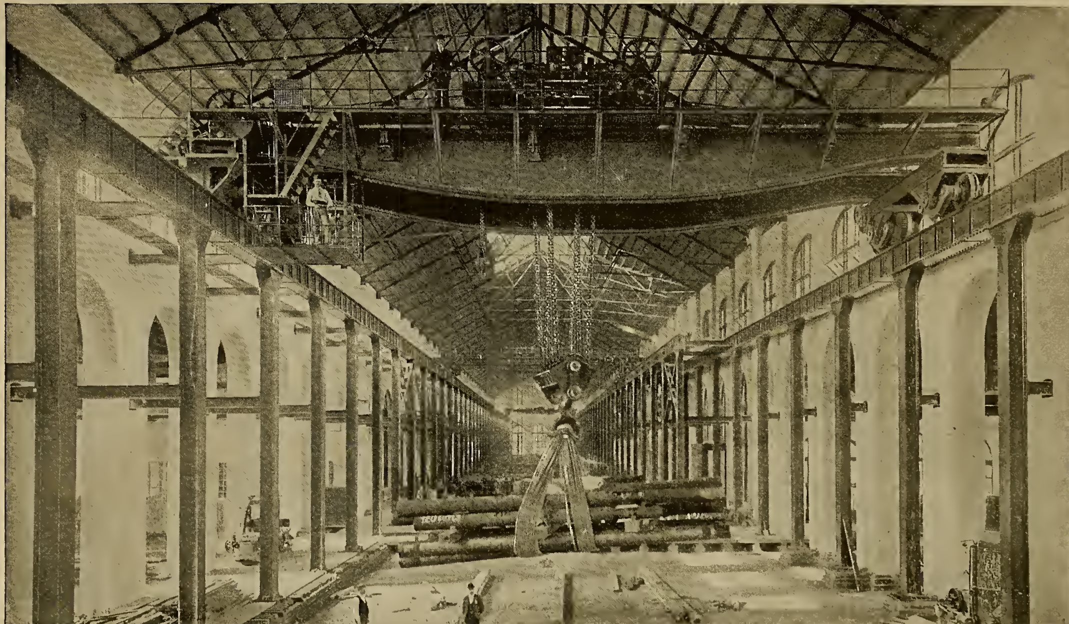


FIG. 1.—ELECTRIC TRAVELING CRANE AT WATERVLIET ARSENAL, TROY, N. Y.

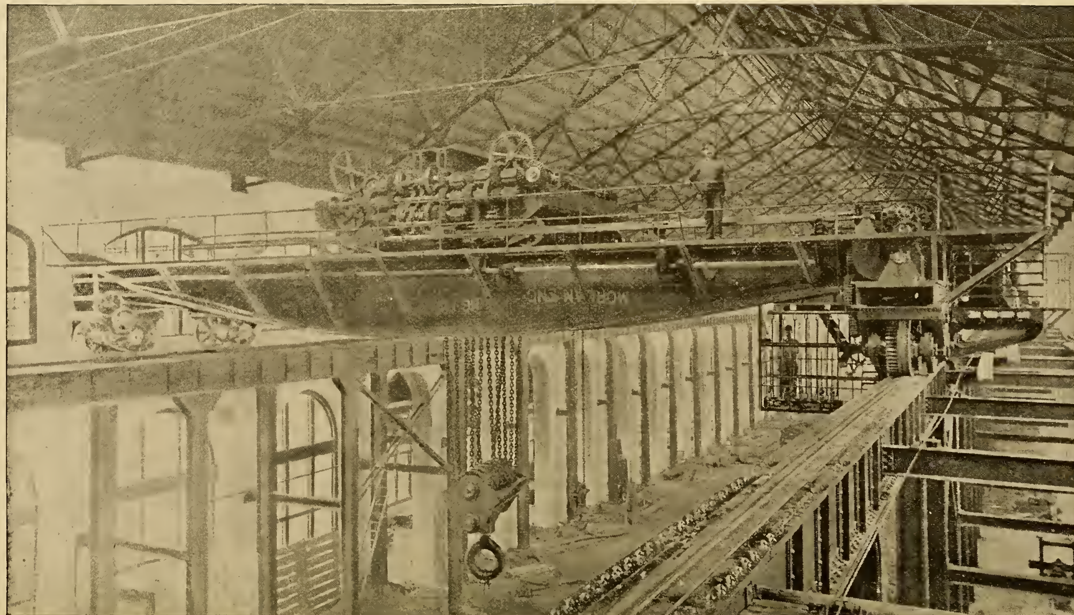


FIG. 2—ELECTRIC TRAVELING CRANE AT WATERVLIET ARSENAL, TROY, N. Y.

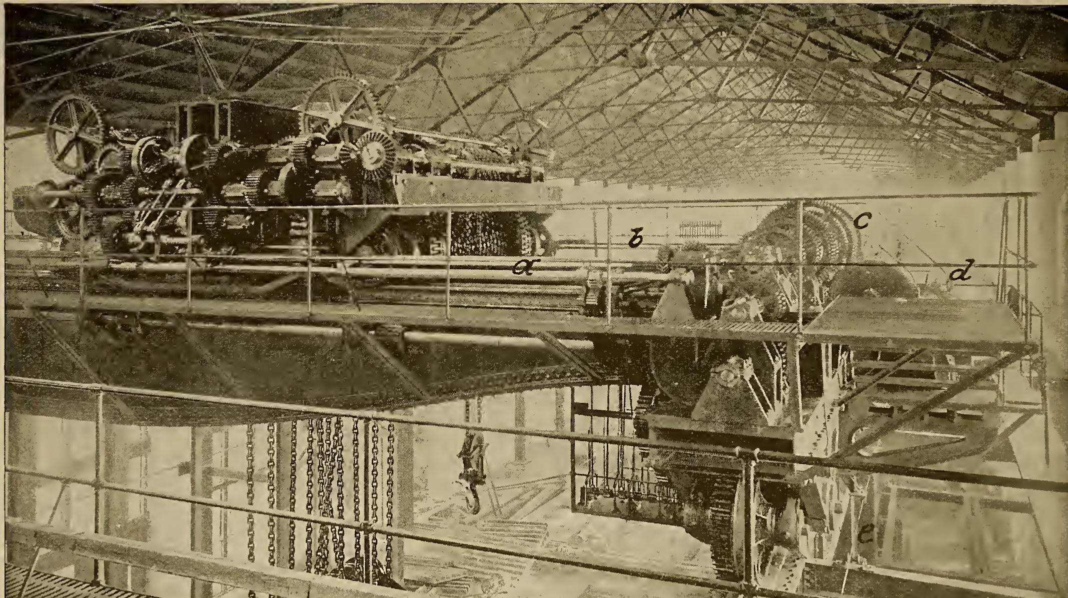


FIG. 3.—ELECTRIC TRAVELING CRANE AT WATERVLIET ARSENAL, TROY, N. Y.

sustain the load in any position. The trolley is provided with two grooved chain-drums, each being capable of winding 250 feet of $1\frac{1}{4}$-inch wrought-iron main hoisting chain. These chain-drums revolve loose on trolley axle-shafts 7 inches in diameter, with bronze-bushed bearings of 24 inches length at each end of drums.

The lower chain-sheave block contains 6 bronze-bushed sheaves of 30 inches diameter, while the upper block contains 5 sheaves of 33 inches diameter, each of which swivels independently of the others. The chain is rove twelve times through the sheaves. The chain-drum of the auxiliary hoist is located above one of the main chain-drums, and is grooved for a $\frac{3}{4}$-inch chain or sufficient length for 56 feet hoist

The operating cage contains all manipulating levers, also the main switch, rheostat, etc., and all motions of the crane can be in operation simultaneously.

All gears of the crane mechanism are carefully cut, except the gears on the chain-drums, which are cast. All bearings have bronze bushings. All working surfaces are finished smoothly and all parts are carefully adjusted.

But notwithstanding all possible care with respect to the construction and the arrangement of the crane mechanism, a great percentage of the driving power is absorbed by friction—and the maximum efficiency of the main hoist is only about 40 per cent. the lowest efficiency is about 20 per cent.

It may reasonably be assumed that the friction in the mechanism for the bridge travel and the trolley travel attains similar proportions, as given for the hoist; and that the efficiency ranges from about 25 per cent. for the slowest speeds, with the greatest number of gear trains in operation, to about 50 per cent. for the highest speeds, with fewer parts in operation.

The figures in the table permit various calculations as to the frictional resistance in certain parts of the crane, as follows:

Theoretical work of hoisting 120 gross tons 2 ft. p. m.=	16.3 H.P.=24.3 amperes.
Actual work of hoisting 126 gross tons 2 ft. p. m.=	50.27 H. P.=75 amperes.
Frictional resistance in crane=	33.97 H. P.=50.7 amperes.
Actual work of operating hoist 2 ft. p. m. without load	=10.05 H.P.=15 amperes.
Frictional resistance due to the load of 120 tons	=23.92 H.P.=35.7 amperes.

It was observed that the power required to bring the crane mechanism up to speed from the state of rest is considerable, and is from about 30 per cent. to 150 per cent., in excess of the power required for keeping an operation in continuance.

GAUGES FOR REGISTERING HIGH-PRESSURES.*

By F. Budenberg.

A PRESSURE gauge, for registering the pressure of highly compressed gases, such as the gases contained in tanks used in connection with the oxyhydrogen lantern, consists, as ordinarily made, essentially of a tube of elliptical section bent to the form of a semi-circle, one end being screwed to a boss through which the gas under pressure is admitted to the tube, whilst the other end is free to move, being simply closed by means of a brass cap screwed on to the tube. When pressure is admitted to such a tube, the section has a tendency to change from the elliptical to the circular form, and, in consequence of this action, the curvature of the tube is reduced. The tube, in other words, shows a tendency to straighten, causing the free end of the tube to move away from the boss, and the degree of this movement indicates the amount of pressure which has been brought to bear on the tube. The movement is magnified by the aid of a toothed quadrant which is in gear with a pinion carrying a pointer, and the latter indicates the pressure on a graduated scale, the whole being mounted in a manner shown in Figs. 1 and 2. In order to insure accuracy of indication, it is of primary importance that all the parts of a gauge be fitted up in the nicest possible manner, so as to obtain perfect freedom in the various joints and bearings without the slightest play in the direction of movement. Any such play or back-lash would be magnified by the multiplying gear, and render considerable variations on the scale of the dial. A slight back-lash between the teeth of the quadrant and the pinion is, of course, unavoidable, and in all well-made gauges this is taken up by means of a fine spiral hair spring.

The most important part of the gauge is the tube, and the reliability of a gauge depends chiefly upon the choice of the material for the tube, and the care bestowed upon its manufacture and testing. For indicating ordinary boiler pressures of, say, about 100 pounds per square inch, tubes made of copper alloy are ordinarily employed; but, for the high pressures which have now become customary in the storage of these gases, gauges with steel tubes are nearly always used. Some gauges are fitted with drawn steel tubes turned out of solid steel which has been specially selected and is suitable for this purpose.

Tubes are used which will safely stand a pressure of 360 atmospheres without taking the slightest "set," the diameter of the tubes before being flattened being about one-half inch, with a wall thickness of nearly one-sixteenth inch. After the tubes have been turned they are polished inside and out, to remove every trace of tool marks, and they are then microscopically examined by light reflected from a mirror, any tube showing marks of scratches being rejected as unfit for use. The tubes are then carefully flattened and bent at a moderate heat, and to perform these operations with entire satisfaction necessitates the greatest experience and skill. Finally, the tubes are hardened and tempered, and a great deal also depends upon the

* From a lecture delivered before the Lantern Society, London.

manner in which these operations are performed. The tubes are then again carefully examined, and if proved satisfactory they are subjected to a series of tests. For this purpose each tube is temporarily attached to a special testing apparatus, the free end being connected with a mechanism which is identical in all its main features with the works of the gauge which the tube is intended to fit. The tube is then submitted to a pressure of 360 atmospheres for one hour, or longer if possible, and careful note is taken, when the pressure is released, whether the pointer of the facsimile gauge returns to zero. If not, the tube is rejected and destroyed, a strict rule being made never to temper a tube twice, in case the first attempt should have proved a failure. The bursting strength of a tube successfully completed in this manner will be between seven and eight tons per square inch, or exceeding 1000 atmospheres ; but these are by no means the strongest tubes that can be manufactured, and gauges have been made which indicate regularly and successfully pressures up to thirty tons per square inch, or 4500 atmospheres, being nearly forty times the highest pressure employed in oxygen cylinders. The tube is next attached to the carrier boss, and the cap is screwed on to the free end of the tube, the metallic joint at both ends of the tube being made by means of a sharp edge projection, which is turned on each end of the tube, and beds itself into the material of the boss and cap. The multiplying mechanism is next fitted up, the several parts being made before hand in large quantities and by special machinery. The gauge is then secured in its case, whereupon it is again attached to a test pump. The multiplying mechanism is now adjusted, so as to give the required range of movement to the pointer, and the dial having been temporarily inserted, the scale is marked out point for point by comparison with two large standard test gauges, which are periodically tested upon a dead-weight frictionless testing machine specially constructed for this purpose. Each dial is written by hand, and is subsequently inserted into its gauge and secured by means of three screws. The pointer is then fastened to the pinion spindle, the gauge is completed, and submitted to another final test upon the hydraulic test pump. A gauge made in this manner will, if fairly used, permanently indicate on the dial any pressure with extreme accuracy, and may be kept under constant pressure without liability to deterioration.

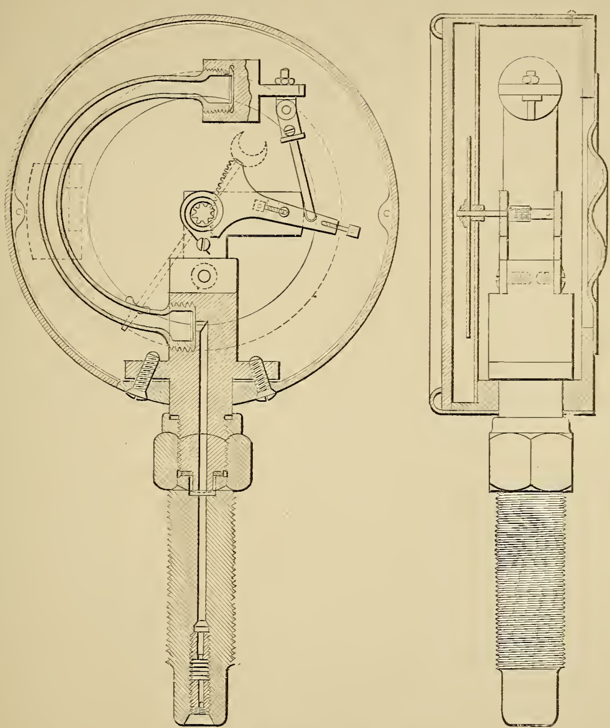
There are, however, a large number of gauges in use which do not comply with these essential requirements, some specimens placed upon the market being, indeed, very inferior in construction and workmanship ; and as there is little to distinguish these gauges in external appearance from efficient instruments, it may be useful to indicate a few simple tests by which the grossest faults, at any rate, can be discovered by any one. For this purpose it is only necessary to remove the brass rim and glass, and to fix the gauge upon a gas cylinder charged to the full pressure of 120 atmospheres. Before opening the valve lift the pointer over the pin against which it rests, when there is no pressure on the gauge. By means of a pencil, mark upon the dial the exact spot where the pointer settles, then lift the pointer back and open the valve. After leaving the gauge under pressure for, say, a quarter of an hour, or better still, half an hour, close the valve, release the pressure, and after again lifting the pointer over the rest pin, observe whether the pointer comes back to the exact position which it occupied before. If there is a perceptible variation the tube has given way, and this forms conclusive evidence that the gauge cannot be relied upon. A more rigorous test consists in making the same experiment under the maximum pressure to which the gauge is marked, say to 250 atmospheres, or even to a pressure exceeding this, and any well made gauge will easily stand the test.

The above tests, which any one interested may perform, will suffice to bring to light the worst defects. When the gauge is under pressure the pointer

should be gently moved both ways, and it should be observed whether it invariably returns to precisely the same indication. Any variation would be the result of back-lash or sticking, and points to inferior workmanship.

To guard against bursting of the gauge case by accumulation of pressure within it, the best safeguard consists in fitting the gauge case with openings or other free vent, combined with a check in the inlet to the gauge. The latter will prevent the sudden admission of pressure to the gauge, and any pressure which might otherwise slowly accumulate in the gauge case will be relieved by the vents in the case.

In a gauge recently manufactured the vent has taken the form of a loose hinged back or valve, which is held close by means of a light spring. If even a very light pressure is admitted to the case, this valve will be forced open, and the pressure is then instantly relieved. The entire efficiency of this safeguard has been experimentally demonstrated.



GAUGE FOR REGISTERING HIGH PRESSURES.

Explosions have sometimes taken place in gauges attached to oxygen and hydrogen cylinders, which Mr. Budenberg attributes to chemical causes. In his opinion they are produced by the ignition of oil or other inflammable matter in the tube, the heat necessary

to effect the ignition being the result of the sudden compression of the air or other gas in the gauge and connections. When the valve of the cylinder charged to 120 atmospheres is suddenly opened, the whole of the contents of the connections to the regulator and gauge are instantly compressed to the 120th part of their former volume into the most distant parts of the internal passages, such as the extreme end of the gauge tube. Setting aside the effect which the mixing of the gases will have, the action is similar to what would occur if the contents were compressed by a piston. In this way sufficient heat is set free to raise the temperature of the compressed body of air or other contents to a considerable degree ; and this will suffice to ignite any highly inflammable matter that may have lodged in the extreme end of the tube or connector.

If such a gauge is applied in an oxygen cylinder immediately after use on a hydrogen cylinder, and the valve is opened suddenly, the heat set free will be sufficient to fire the mixture of oxygen and hydrogen in the end of the tube, and this in turn will ignite the oil in the tube with the result that a violent explosion will occur, owing to the rapidity and intensity with which the oil is consumed in the presence of oxygen ; but even without having hydrogen present, the heat evolved by a sudden opening of the valve may be sufficient to ignite directly any oil that has gained access to the tube.

Since the danger of the presence of oil in these gauge tubes has come to be realized, the makers have discontinued the practice of using oil for dividing and testing these gauges, pumps filled with water having been adopted instead, and the greatest care is exercised to prevent any oil from coming into contact with the gauge fittings during manufacture. Special water pumps are now set aside purposely for this work, and the connections are so arranged that it is impossible for any workman to screw the gauges on to an oil pump without providing himself with a special connection for this purpose—all chances of a mistake being thus overcome. The pumps themselves are fed from the town water-works, and after each test, the contents of the pumps are discharged into a white enameled trough, in which any traces of oil can easily be detected. Subsequently, the contents of the tube are extracted by means of a vacuum pump and are examined for oil. Finally, the remnants are blown out by admitting air pressure to the gauge at 100 or 120 atmospheres, and suddenly releasing this pressure. In this manner everything that human foresight can provide is done to minimize the chances of the tube containing, when completed, even the slightest traces of oil. But, in spite of every care, the entire absence of oil or other inflammable matter cannot be absolutely assured ; and even if this were done, there always remains the danger of oil gaining access to the tube accidentally when a gauge is in use. Therefore, whilst continuing to exercise every care to keep away all traces of oil, the ultimate safeguard against accidents of this description must be looked for in another direction, namely, by checking the sudden inrush of gas to the gauge when opening the valve, so that the pressure in the gauge rises gradually, and the heat involved has time to be absorbed by the material of the gauge tube. This may be accomplished by opening the valve very gently ; but, as this gentleness cannot always be insured, owing to the frequent stiffness of the valves, carelessness, and want of skill, it is indispensable, in order to secure perfect safety, to fit each gauge with some means for automatically checking the admission ; and, whatever check is employed for this purpose, it must not require any particular attention or manipulation. Various devices have been brought out for this purpose. A check patented by the Manchester Oxygen Company is an excellent one. This consists in screwing a plug, through the centre of which a fine hole has been drilled, into the foot of the connecting shank of the gauge. Upon this plug are placed a number of alternate layers of copper-wire gauze and felt cloth, in the manner shown in the illustration.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

By F. Houghton.

Third Paper.

HENRY GEORGE KLOPPER Ketchum, Member of Council of the Canadian Society of Engineers, and Member of the Institute of Civil Engineers, London, was born at Fredericton, New Brunswick, on the 26th of February, 1839. He was educated at the Collegiate Grammar School under the late Dr. George Roberts, M. A. At an early age it was agreed that he should be apprenticed to the late Frank Wells, architect of the English Cathedrals of Montreal and Fredericton, but owing to the death of that gentleman his attention was diverted to the study of civil engineering. In 1853 Mr. Thomas McMahon Cregan, of Limerick, Ireland, was engaged by Kings' College University, of New Brunswick, to deliver lectures on the practical method of surveying and engineering at the University, and as this accorded with the intention of his parents, Mr. Ketchum undertook to study civil engineering with Mr. Cregan, and he obtained the first diploma for civil engineering granted by that university. Mr. Ketchum, however, could not immediately find the employment for which he was thus fitted, but he underwent and passed an examination as a deputy land surveyor for the government of New Brunswick, and his commission as such was signed by the Hon. James Brown, surveyor-general of New Brunswick. Mr. Ketchum, however, could not thus suffer himself to be idle, so he undertook the study of telegraph operating, which was then in its infancy in Canada. He was one of the first to read the messages transmitted by sound instead of the usual "tape" then in vogue, and the knowledge of business he acquired in the telegraph office was of the greatest service to him in after life. It was not long, however, before Mr. Ketchum had an opportunity of applying his talents to the profession of which he has since acquired considerable fame.

In 1856 he received the appointment of "axeman" at a dollar a day, under Henry F. Perley, late Chief Engineer of the Public Works of Canada, who was then resident engineer on a line of railway connecting the waters of the Gulf of St. Lawrence with those of the Bay of Fundy, called then by the grandiloquent name of the European and North American Railway. This railway had been begun by a most celebrated firm of English contractors, Messrs. Peto, Brassey, Betts & Jackson, the contractors of the Grand Trunk Railway of Canada, but the government of New Brunswick, after these contractors had done a considerable part of the work, thought fit to purchase their interest in the undertaking and carry it on by themselves under the direction of Mr. Alexander Luders Light, M. Inst. C. E.

Mr. Light soon discovered Mr. Ketchum's abilities and appointed him as chief draughtsman on his staff, and thereafter Mr. Ketchum's position as an efficient officer was secured. He served under Mr. Light four years, not only as draughtsman, but as assistant engineer on every part of the line of railway from St. John to Shediac, wherever his services were required. It is remarkable that his professional career began on the Isthmus of Chignecto, on an ordinary railway, over which he is now engaged in constructing the first ship-railway of importance in the world.

After the works on the European and North American railway were finished, which now comprises the

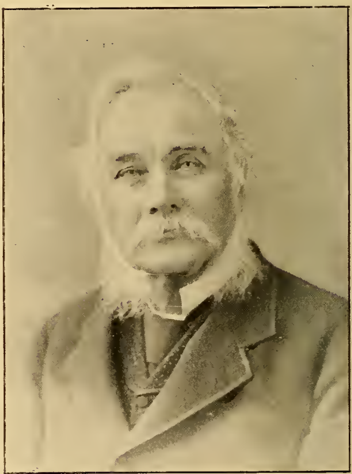
most important part of the Intercolonial Railway of Canada, Mr. Ketchum was offered an appointment in the Empire of Brazil on the celebrated San Palo

H. G. C. KETCHUM, MEMBER OF COUNCIL.

railway. He was occupied there about five years, during which time he was employed first on the staff of the late Sir James Brunlees in locating that railway and afterwards as engineer and agent of the chief contractors, Messrs. Robt. Sharp & Sons. During his time there he assisted in the construction of the famous Mogy inclines, the large Mogy viaduct, the Cachoeira tunnel, and various other works. So satisfied were his employers with his work in the erection of the Mogy viaduct that they made him a present of £500 on its completion. This viaduct was 180 feet high, and of 12 spans, on an incline of 1 in 9.75, and a curve of 24 chains radius. It was constructed of iron columns on granite piers, and took only seven months to erect under Mr. Ketchum's superintendence, for which short space of time he was fully entitled to the gratuity before mentioned. The inclines were four in number, and the grades about 600 feet to the mile and five miles long, and cost $1,000,000 a mile.

In 1865 Mr. Ketchum left Brazil on account of his health and the completion of his work. He was then offered a lucrative position in India under the present President of the Institute of Civil Engineers, Mr. Berkley, but he refused it to return to his native land. Sir John C. Allen, present Chief Justice of New Brunswick, the late Sir Albert J. Smith, and Sir Charles Tupper were then in London engaged in the negotiation of the contract with an English company for the construction of the Moncton and Truro railway, now part of the Intercolonial railway of Canada, and on their recommendation he was sent out as engineer to locate and construct a part of that railway lying in the province of New Brunswick.

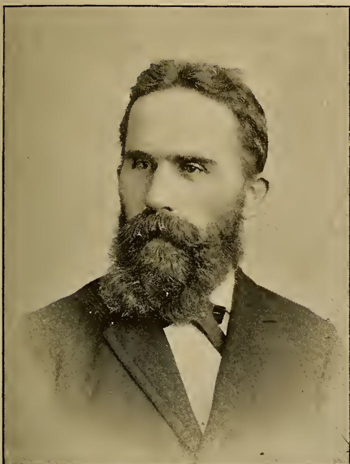
Mr. Ketchum soon found himself again on the Isthmus of Chignecto



COL. SIR CASIMIR GROWSKI, A. D. C., K. C. M. G., M. INST. C. E., PAST PRES'T AND HON. COUNCILLOR.

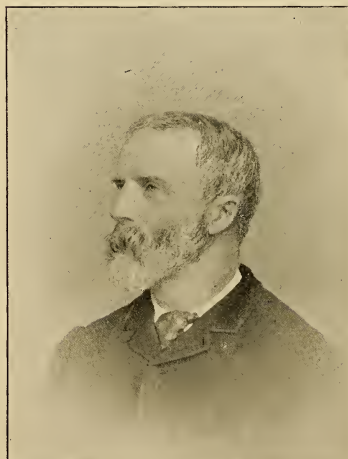
prosecuting a survey of this line of railway. After spending some time on the surveys he was appointed agent of the International Contract Company of

London, to construct the railway in New Brunswick. This company failed; liquidators were appointed, and under them he retained his position. The interest in the contract was sold by the court under Vice-Chancellor Sir John Stuart to Messrs. Edwin Clark Punchard & Co. Mr. Clark asked Mr. Ketchum whether he would undertake the completion of his railway for his estimate and Mr. Ketchum complied. It is the very life of an engineer to make his estimate good, so Mr. Ketchum undertook the contract thus challenged, and made a lot of money out of it. Mr. Ketchum believes it to be the most important vocation of an engineer to make good his estimates as a *sine qua non*. His reputation depends on it in a very great measure and Mr. Ketchum's estimates have always proved reliable. Mr. Ketchum would, however, after this undertaking engage in no more contracts, because of the great turmoil and anxiety connected with contracting, and he believes there is nothing in the world more laborious and worrying than a contractor's life and that they should all deserve what they get and more besides.



J. D. BARNETT, MEMBER OF COUNCIL.

We have not yet come to the end of Mr. Ketchum's career, but rather the beginning of it, for who can tell what will result from his introduction of ship railways? We have alluded to his employment in the Isthmus of Chignecto, first as an assistant to Mr. Perley on the Moncton and Shediac Railway, across the isthmus, where cargoes were transhipped from vessels on the one side to steamers on the other side by means of an ordinary railway. After years of study, not only of the ground over which ships are to be transported, but also of the tides and harbors at each terminus, after the most careful investigations and surveys conducted at his own expense, we find him constructing the Chignecto Ship Railway in Canada with Sir John Fowler and Sir Benjamin Baker associated with him as chief engineers of this great and novel undertaking. The success which he has had in this venture, even if his other experience did not warrant it (which it might certainly do), places him in the front rank of successful engineers.



H. G. GAMBIE, MEMBER OF COUNCIL.

A full description of the Chignecto Ship Railway and of ship transportation by Mr. Ketchum may be seen in the Transactions of the Canadian Society of Engineers for 1892. The ship railway is already three-fourths completed and a contract has lately been entered into for its completion by first July, 1894, an extension of time having been granted by the government of Canada.

F. C. GAMBLE, MEMBER OF COUNCIL.

Mr. F. C. Gamble, was born in Toronto on the 23d October, 1848. In 1869 he began his engineering career as a chainman on the Intercolonial Railway, in 1871 acting as rodman on the Great Western Railway, of Canada. Later on, in the same year, and in the employ of the same railway company, he became assistant engineer, which post he held till some time in the year 1872. From 1873 to 1875 he became resident engineer for the contractors of the Prince Edward Island Railway. In 1876 he removed to the Intercolonial Railway employ and became one of the assistant engineers for the company. From 1876 to 1877 he occupied the same position for the Georgian bay branch of the Canadian Pacific Railway, and from 1877 to 1878 was assistant engineer on the Quebec, Montreal and Ottawa Railway. In 1879 he practiced in Toronto. From 1879 to 1880 he was assistant engineer on Contract 42 of the Canadian Pacific Railway. He was then employed on the staff of the same company in British Columbia, where he gained an excellent experience of the roughest kind of railway work. In 1881 he left the company's employ to accept the position of assistant engineer in the Department of Public Works of Canada, in British Columbia. In 1887 he became resident engineer and agent in the same department, which position he still occupies. At present the works under his supervision embrace the Esquimalt grading, dock, harbor and river works, such as the removal of submarine rocks in the harbors of Victoria and Nanaimo, dredging operations, the improvement of the channel, five miles in length, through the sandbanks at the mouth of Fraser river, where the extreme range of the tide is 14 feet, and other minor works tending to improve navigation and protect the banks of several other rivers in the province. He also has charge of the erecting and repairing of public buildings in British Columbia. Mr. Gamble was elected a member of the Institution of Civil Engineers of England, on the 3d March, 1891, and a member of the American Society of Civil Engineers on the 1st April of the same year.

Mr. P. Alex. Peterson, whose portrait was printed in the first part of this article in the November issue, is one of the vice-presidents. He is a Canadian by birth. He began his studies at a private school near Niagara Falls, afterwards finishing at the Toronto University, in the year 1862. About 1859, while still at college, he was articled to Mr. T. C. Keefer, who was then practicing engineering in Toronto. At the expiration of his term of apprenticeship he became Mr. Keefer's partner, remaining with him till the year 1866, when he left Toronto to take charge of a division of the Great Western Rail-

way, which position he filled till 1867. He then went to the United States, where he took charge of surveys from Oneida to Oswego for the New York and Oswego Midland Railway Company, afterwards becoming one of its resident engineers. In March, 1868, he left that company's employ, and returned to Canada to take charge of a survey party in New Brunswick for the Intercolonial Railway Company. On completion of the survey he was given charge of the construction of the Bathurst division, which position he resigned in 1872 to become chief engineer of Toronto water works. Here his services were evidently highly appreciated, for in September, 1875, on tendering his resignation to accept the position of chief engineer of government railways for the province of Quebec, it was promptly declined, his services being retained by the city until the close of the year 1876. While employed by the provincial government Mr. Peterson gained a varied experience in bridge construction, being engineer in charge of the Bastican bridge over the Bastican river, the St. Maurice river bridge, the Chaudiere bridge crossing the Ottawa river above the Chaudiere falls, besides numerous other less important structures. In 1881 he resigned the position in the government to become chief engineer of the St. Lawrence river bridge erected by the C. P. R., spanning the St. Lawrence river at the head of the Lachine rapids. This most important work, requiring ability and professional knowledge of a high order, he carried to a satisfactory conclusion. He then took charge of the Sault Ste. Marie river bridge, a structure of almost equal importance. Shortly after the completion of this last work he was elected chief engineer of the extensive system of the Canadian Pacific Railway, which position he at present occupies. In 1874 Mr. Peterson was elected a member of the Institution of Civil Engineers. In 1876 he became a member of the American Society of Civil Engineers, and is now one of the members of its council.

Mr. Hugh David Lumsden was born at Belhelvie Lodge, Aberdeenshire, Scotland, on the 7th September, 1844. He is the youngest son of the late Colonel Thomas Lumsden, C.B., of Belhelvie Lodge, Aberdeenshire, Scotland. Mr. Lumsden was educated at the Belhelvie Academy, Aberdeen, and at Wimbleton School, Surrey, Eng. He joined the Thirty-fourth Battalion as lieutenant of No. 7 company in 1867, and received a second-class M.S. certificate in July of the same year, continuing in that position until promoted to the captaincy of the same company about the year 1876, when, owing to constant absence, he was allowed to resign, retaining his rank. The date of his coming to Canada I do not know. During the year 1870 he was reeve of the township of Eldon, in the county of Victoria, and president of the Eldon Branch Agricultural Association for that

H. D. LUMSDEN, MEMBER OF COUNCIL.

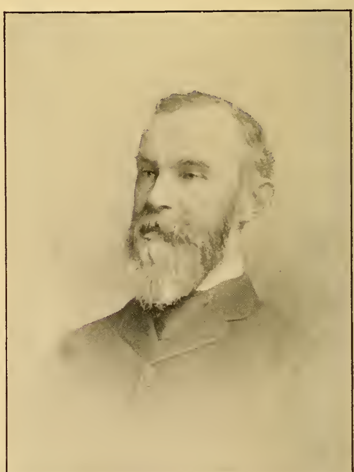
year. From October, 1870, to April, 1871, he was engineer in charge of the locating party on the northern part of the Toronto and Nipissing Railway, under Edmund Wragge, C.E. From May to August, 1871, he located a portion of the Toronto, Grey and Bruce Railway. Then from August to No-

vember, 1871, he took charge of a survey for the Northern Railway from Penetanguishene to Coldwater. From December of the same year to December of 1872 he was employed on the Northern Railway, under Mr. Moberly. From the beginning of January, 1873, to December, 1874, he was engineer in charge of the Credit Valley and Victoria Railways; from May, 1875, to June, 1876, was in charge of a survey party for the contractors of the Georgian bay branch of the C. P. R., Mr. Murdock being chief engineer; from August, 1876, to July, 1879, was in charge of surveys for the Dominion government; from May, 1880, to March, 1881, was in charge of a party on a survey of the northwest territories for the C. P. R., from Bird-Tail Creek northwestward, and from March, 1881, to November, 1884, was chief engineer of the Ontario and Quebec Railway. He has been from the latter date to the present engineer on the Canadian Pacific Railway. Mr. Lumsden is a Dominion land surveyor, a provincial land surveyor for Ontario, and a member of the St. Andrews' Society of Toronto, and was elected a member of the Institution of Civil Engineers, of England, in March, 1885.

JOSEPH HOBSON, M. INST. C.E., MEMBER OF COUNCIL.

Mr. Joseph Hobson is a Canadian by birth, having been born in Ontario. His early experience was principally on land surveys. He then became resident engineer on the construction of the International Railway bridge at Buffalo. He then worked under Mr. Thomas Keefer as chief assistant on the Great Western Railway. On Mr. Keefer's leaving, he succeeded him as chief engineer, which position he retained until some time after the amalgamation of that road with the Grand Trunk Railway. Until recently the Grand Trunk Railway system had been divided into four divisions, each having a chief engineer. Now the two smaller divisions have been added to the two larger, making two divisions in all, of one of which Mr. Hobson has charge. Mr. Hobson's chief work was the construction of the St. Clair tunnel.

Alan Macdougall, the third son of the late Lieutenant-Colonel John Macdougall, is a native of Edinburgh, Scotland, and was educated partly at a private school and at the Edinburgh Academy.



A. MACDOUGALL, M. INST. C. E., MEMBER OF COUNCIL.

In 1859 he was articled to Mr. Charles Topp, member of the Institution of Civil Engineers, consulting engineer to the North British Railway Company, under whom he had charge of the construction of the Dalkeith and Ormiston branches of the North British Railway. He came to Canada in 1868, and was employed on the Narrow Gauge Railway, having charge of preliminary surveys of the Toronto, Grey and Bruce Railway, and afterwards of the construction of the first 60 miles as chief assistant to Mr. Edmund Wragge, member Institution of Civil Engineers. With this road he severed his connection in 1871, to take charge of the North Grey extension of the Northern Railway of Canada, under Mr. C. W. Moberly. Then for the four following years he was in the Department of Public Works, engaged on harbor and river improvements on the western lakes and river St. Lawrence, under Mr. W. Kingsford, C. E., LL.D., F.R.S.C. In 1877 he returned to Scotland for a few years, and on his return to Canada began practicing as a consulting engineer in Toronto, where he has been largely employed in municipal and private works, designing sewerage and water works systems for a number of towns all over Canada. Owing to his large experience in sanitary matters, Mr. Macdougall is now a recognized authority on that interesting and vital question. His advice is eagerly sought after, his evidence carrying weight in the courts. Two years ago he was for a short time city engineer of St. Johns, Newfoundland, where a well earned address was tendered to him by the board of health for services rendered during an outbreak of diphtheria, and an offer made of a permanent appointment, which he was unable to accept. Mr. Macdougall was elected a member of the Institution of Civil Engineers and a fellow of the Royal Society of Edinburgh in 1877. He is also a member of the British Association for the Advancement of Science and the American Public Health Association. The credit of founding the Canadian Society of Civil Engineers is largely due to Mr. Macdougall, who takes an absorbing interest in its welfare. He has been secretary of the society, and has served on the council several times, and is now at the head of a movement, which it is to be hoped every engineer will join in, to make the profession a close one, and to have a "college" similar to medicine, law and divinity, the degrees or license to practice to be granted by the Canadian Society of Engineers.

INFLUENCE OF PATENTS ON AMERICAN INDUSTRIES.—II.

By Leon Mead.

THE writer in the preceding article endeavored to summarize the history of the patent office and to point out some of the disadvantages and misfortunes which might have irremediably crippled a less sturdy institution. It is the purpose in this concluding paper to show in what manner patents have affected the American people and American industries, and to offer some specific comments concerning certain inventions that have infinitely multiplied the activities of the world's commerce and lessened the burdens and increased the comfort of the human family.

Within the last century the results of well-directed inventive genius have been simply incredible. The horse-power machinery which, within the memory of living men, supplanted the primitive flail in separating grain, has in turn been largely superseded by the wonderful steam-power thresher and separator. Less than one hundred years ago, Charles Newbold of New Jersey patented the first iron plow. For a long time people regarded it with distrust. Many went so far as to declare that by using such a monstrosity they would poison the soil. Were Charles Newbold alive to-day, with what awe, think you, would he study the appliances which increase the acreage of the farmer and triple his harvest? To demonstrate the material benefits of patents to the agriculturist, we have but to compare the rude inventions of Obed Hussey and others of sixty years ago, which, however, were the precursors of the modern mower and harvester to the cord-binder, which "automatically passes a cord around each bundle, knots it, cuts the cord and discharges the bundle at one operation."

Thomas Saint obtained a patent in England, September 17, 1790, for an awkward contrivance which, nevertheless, contained the suggestion which is amplified and brought to perfection in the sewing machine of to-day. He discovered a rude method of forming, automatically, a chain stitch, and therein lay the great principle of the invention. But it was reserved for Elias Howe to practically apply that principle, nor can it be questioned that the invention in its entirety was original with him. Howe's career furnishes another touching picture of the trials and disappointments which so many inventors have encountered in their struggles to secure and maintain their rights and to protect their interests; though his is a rather exceptional case, in that he eventually amassed a fortune. He was born and spent his early boyhood in a rural Massachusetts town. His father earned a meagre livelihood both as a farmer and miller. From birth Elias was lame in one foot, and his health during his youth was extremely delicate; in fact, he was never strong. At sixteen he went to work in the Lowell mills on a mere pittance. His great pleasure was the study of machinery. Two years later he found employment in the Waltham mills. In the same establishment his cousin, Nathaniel P. Banks, who later was to attain great eminence as a Major-General, a Speaker of the House of Representatives, a Governor of Massachusetts, etc., had charge of a loom.

At twenty, stimulated in spirits by his dreams of becoming an inventor, but still fragile in health, Howe went to Boston and became an assistant to an old inventor, who kept a shop in Cornhill. On a stipend of nine dollars a week he challenged fate by falling in love and getting married, and soon afterward he fell ill. During his slow convalescence he was brought face to face with the grim destitution that encompassed him. He was driven nearly mad by the thought that his wife and child would perish of starvation if he did not rouse himself to action. One day, while sitting beside his industrious wife in their all but squalid abode, and watching her fingers as they busily plied the needle, the thought, like a revelation, suddenly flashed across his mind that a machine might be constructed which would take fifty stitches while his wife was taking one. Convinced that the idea was not impossible of realization, he began experimenting. A needle with both ends sharp and the eye in the middle was his first vague plan; but, finding that out of the question, he made a rough model with pieces of wood and wire—assured that he was at last on the right track. Within a short time, a friend, George Fisher, loaned Howe five hundred dollars to pursue his experiments. When six months later he submitted his first completed machine, which was nearly twenty inches high, to the Boston tailors, some of the latter taunted him with jeers and ridicule; others expressed the belief that if the machine were brought into use it would ruin the tailoring trade. At all events, he could not find a single purchaser. His money was exhausted, and physical infirmities rendered still more hopeless his lot. For a period the charity of friends was his sole dependence. Having with great difficulty raised sufficient funds to buy a steerage passage, he crossed the ocean in a sailing vessel. In London he was tricked by a capitalist after the latter's workmen had learned how to operate the sewing machine Howe had entrusted to him. Pawning his clothes to pay for the most humble fare, Howe worked for four months constructing another machine, which he disposed of for twenty-five dollars. Then, in the capacity of a steerage cook, he worked his way back to New York. On his arrival he was shocked by the intelligence that his faithful young wife was dying. Not having sufficient money to get to Cambridge, Mass., where his family was living, he immediately sought and soon found employment in a New York machine shop. As soon as he had earned the necessary funds, he started for home, reaching his wife's bedside just in time "to see the flickering life go out." He followed his dead helpmate to the grave in a suit of borrowed clothes. All through these hardships and afflictions Elias Howe kept a steady faith and never once despaired. Finally, he secured his first patent on the tenth of September, 1876, and within a short time his sewing machine was introduced and found its way into untold homes to lighten the labor of women in every civilized part of the world. His invention yielded him an income of $200,000 a year when he was but thirty-five years of age. His wealth was estimated at $2,000,000 when he was forty-eight years old. One of the beauties of his character was that early troubles had not hardened or embittered him. He responded benevolently during his later life to all reasonable calls of charity. When doing kind and generous deeds for women in distress, he doubtless always had in mind the devoted wife whom Providence had not been pleased to let share with him the fame and riches that finally were his. Honored, and still in the prime of life, Elias Howe died shortly after the close of the civil war, in which he served with heroic zeal as a private. There is a deep, solemn and impressive moral in such lives, and their story cannot be too often told to the rising generation. Thus Howe paved the way for the improvements and developments of the sewing-machine made by Allen G. Wilson, who was forced to make pitiable sacrifices on account of poverty, and by Isaac M. Singer, Grover and Baker and others.

No realm of human activity has been ignored by our inventors, and it may truly be said that they have met all the demands of modern civilization. Improved plumbing, new sanitary drainage systems, paving, and other hygienic inventions, are shown by statistics to have actually reduced the death rate 5.79 per thousand people within the past twenty-five years in the city of New York, thus representing a saving of about three thousand lives yearly.

Let us consider briefly what nineteenth century invention has done for "the art preservative of all arts." American inventors have excelled all others the world over in bringing to its present state of superlative excellence the printing-press, "the great engine by which man is enabled to improve the faculties of his nature; it is the preserver of the knowledge and acquirements of former generations." The present century has produced the improved printing press. The machine devised by Richard M. Hoe, and patented to him July 24, 1847, was considered the incomparable paragon of its day. Inside of five hours it was capable of printing an edition of 130,000 copies of a newspaper. Since then Mr. Hoe has added many valuable improvements to his different presses. The first machine, automatic in its operation throughout, including the feeding and delivering of the paper, was patented to William Bullock in 1863. Another great machine was patented in 1879 to Luther C. Crowell, after several legal bouts in which other inventors endeavored to establish priority. It has been described as a machine "in which a continuous web of paper printed on both sides between pairs of type and impression cylinders, is passed thence to rotating cylinders, which cut the sheets from the web and make in them four folds, delivering them thus folded." The principle of this machine constitutes a type of the leading printing-presses of the day. From the machine of 1810, producing a four-page sheet having a circulation of five or six thousand copies, we have to-day newspapers of thirty-six sheets, with a daily circulation of hundreds of thousands. Such a production by the old press would have required two thousand pressmen, as many more inkmen, and a thousand folders—to say nothing of the thousand duplicate type forms which would have been necessary.

The "vulcanization" of india rubber, which Charles Goodyear accidentally discovered, has made that article adapted to more than a thousand uses, given employment to many thousands of artisans, and enriched this country by scores of millions of dollars. Goodyear died thirty-two years ago at the age of sixty. Nearly all his life was passed in direst penury. He was a peculiar victim of continual adversity. Inconsiderate people called him a "jail-bird," for he was frequently imprisoned; others declared him to be a lunatic, because he sacrificed his own and the comfort of his family to the one great ambition of his life—to perfect the substance technically known as caoutchouc. In the end he succeeded and india rubber was introduced under his patents, but in a pecuniary way he profited little through his great contribution to the commercial and industrial world.

Only casual allusion can be made here to the improvements by American inventors in the locomotive and in railway machinery in general, during the past fifty years. The marvelous evolution in this line is familiar to nearly every one. Not long ago an engine drawing the Empire State express on the New York Central railway ran four miles at the rate of seventy-eight miles an hour, the fastest recorded time, I believe, made on a level by a locomotive drawing a train. Mr. Angus Sinclair, editor of Locomotive Engineering, counted the revolutions of the driving wheels, which at their fastest made three hundred and forty revolutions a minute. By ear and by feeling the counting was done. In an interview with a newspaper reporter he said: "The circumference of the drivers being known it is a simple matter to reckon the rate of speed. Besides this, there is a sort of shock throughout the

locomotive on the down stroke of the driving rod which aids in the counting. This counting has become through practice a mechanical act with me, and on my ride yesterday I was counting, looking after the machinery of the gauge and supplying the gauge with paper on which the diagrams were to be marked, at the same time. So, you see, I had no time to think of being nervous." The locomotive in question was the famous record-breaker, No. 870. Authorities agree that locomotives in the near future will be made which can run at the rate of 100 miles an hour.

The growth of marine architecture has kept even pace with the needs of our age, though we might as well admit that until within the past few years we have not been so actively engaged in shipbuilding as some other nations. Our government, however, has come to appreciate the necessity of a national fleet that the American people will not be ashamed of. In other words, we are going to have a navy one of these days that the greatest maritime powers abroad must respect. The rapid voyages accomplished by the twin-screw steamers Teutonic, Majestic, City of Paris, City of New York, and the Fuerst Bismarck are an earnest that the time is not far distant when twenty-five knots, perhaps more, will be the average speed of first-class "ocean thoroughbreds."

The possibilities of American invention are far from being exhausted. Aerial navigation is no longer scouted as an absurd dream of the scientific fanatic. Some modern wizard, I doubt not, will practically solve the problem of artificial flight, for it has been demonstrated that suspension in the air is comparatively simple. The chief difficulty lies in the evolvement of an effective steering apparatus for the air-ship. When that is devised the Atlantic liners will not be free from a unique and probably a formidable competition.

This is the age of electricity. Though many of its phases are not understood, it has become man's slave, nay, his willing page. Dynamos are generating the inexplicable electric fluid in nearly every city in the United States to-day. Twenty years ago they were practically unknown. Forty per cent. of the street railroad mileage of this country is now served by electric traction. Electricity—in its infancy, so far as its uses to mankind are concerned, but old as the Creator, has already performed mechanical miracles. Perhaps its greatest claim to an admiration bordering on reverence is its effect in cheapening the cost of many luxuries, comforts and necessities of life. It is a grand factotum of the chemist, a friend of the mechanic, and an infinite benefaction to the human race.

The telephone, through which two people 1000 miles apart have easily conversed with each other, the phonograph, which a thousand years hence will be capable of reproducing "Home, Sweet Home," as sung by Madame Patti, and many other recent inventions in which electricity plays a leading role, are perhaps the forerunners of even more remarkable, if at present inconceivable, marvels of creative genius. At the Chicago Fair many visitors will have an opportunity to witness the strides which have been made in mechanical progress since the Centennial Exposition in 1876. The American exhibitors have applied for ten times as much space as was provided for them at Philadelphia. Three times more space is bespoken for foreign exhibitors of machinery at the Chicago Fair than has been occupied by them in any former international fair.

Inventions recorded in the United States Patent Office are the foundation upon which are based the vast majority of our manufacturing industries.

This statement cannot be truthfully controverted. American inventors have contributed more to the material prosperity of this country than any other class. Their inventions and improvements have prodigiously widened the scope of production and furnished the primary agencies by the employment of which our manufacturing interests have reached their present magnitude. The following is a limited list of eminent Americans who have thus so generously

insured our industrial advancement and national welfare: Amos Whittemore, Barton H. Jenks and Erastus B. Bigelow as to looms; John Fitch, Robert Fulton and James Rumsey as to steamboats; Eli Whitney as to the cotton gin; Oliver Evans as to milling machinery; E. I. Dupont de Nemours as to gun-powder; Thomas Blanchard as to lathes for turning irregular forms; Asa Spencer as to geometrical lathes; Peter Lorillard as to tobacco-making; Ira Ives, Eli Terry, Noble Jerome and Chauncey Jerome as to clocks; Jethro Wood as to iron plows; Eliphalet Natt and Jordan L. Mott as to stoves; Samuel W. Collins and Elisha K. Root as to ax-making; Matthew W. Baldwin and Ross Winans as to locomotives; Jesse Reed as to nail-making; Samuel Colt, Ethan Allen, Christian Sharps, Edmund Maynard, Christopher M. Spencer, Rollin White, Horace Smith and Daniel P. Wesson as to fire arms; Richard M. Hoe, Isaac Adams, Stephen P. Ruggles, Andrew Campbell, Moses S. Beach and G. P. Gordon as to printing-presses; William Edwards as to leather-making; John J. Howe and Chauncey O. Crosby as to pin-making; Alonzo D. Phillips as to friction-matches; Thaddeus Fairbanks as to scales; Henry A. Wells as to hat-making; Oliver Ames as to shovels; Charles Goodyear, Nathaniel Hayward and Horace H. Day as to india rubber; William Woodworth as to wood-making; William P. Ketchum and Cyrus H. McCormick as to mowing and reaping; John Ericsson as to naval construction and hot-air engines; S. F. B. Morse, Royal E. House, David E. Hughes and Thomas A. Edison as to telegraphs; Elias Howe, Jr., Allen B. Wilson, Isaac M. Singer, J. E. A. Gibbs, William O. Grover and William E. Baker as to sewing-machines; Jonas Chickering and Henry Steinway, Jr., as to pianos; Linus Yale as to locks; Nathan Washburn and Asa Whitney as to car-wheels; Robert Bruce as to type-casting machines; John H. Barnes as to cotton and hay presses; James J. Mapes as to fertilizers; Cullen Whipple as to wood screws; Henry B. Tatham as to lead pipe; R. P. Parrott as to cannon; Richard J. Gatling as to Gatling guns; John Stephenson as to horse cars; Gail Borden, Jr., as to condensed milk; Henry Disston as to saws; John A. Roebling as to cables, chains and bridges; Henry Burden as to horseshoe machinery; William and Coleman Sellers as to shafting and iron working; Robert L. and Alexander Stewart as to sugar refining; George H. Corliss as to steam-engines; Thomas A. Edison as to incandescent electric lamps, etc., etc.

Immeasurably more has the public profited and been benefited by these inventions than the men whose brains produced them. Every section and all classes have cause to be thankful for what inventive genius has done. It is an old-fogyish and mistaken notion that inventions, particularly in this country, have decreased the wages of working-men and circumscribed manual labor. On the contrary, they have augmented both. Lessened prices and increased consumption are the two great things that are frequently lost sight of by those who inveigh the loudest against modern methods of doing business. While the modern printing-press is an example of a machine which does the work of thousands of men it must be remembered that were those thousands of men required to produce a single modern daily newspaper their wages would soon suggest to the proprietors of that journal the pecuniary feasibility of "shutting up shop." The Boston tailors who refused to give Elias Howe their support, arguing that the use of his sewing-machine would ruin their business, were totally misled by selfish alarm in their misgivings. Listen to the voice of statistics on this point. Out of a population of twenty-three millions in 1850 there were fifty-two thousand tailors, or one tailor to four hundred and forty-two inhabitants. Out of a population of thirty-eight millions in 1870 there were one hundred and six thousand tailors or one tailor to three hundred and fifty-eight inhabitants. During this period the number of tailors increased more than one hundred per cent., while the population, supplying those "Knights

of the Goose," increased but sixty-five per cent. Fifty thousand or more people were employed in the manufacture and sale of sewing-machines during those twenty years, not to mention the thousands that have been thus engaged since 1870. The saving of labor in millions of homes and factories effected by the sewing-machine is beyond exact computation, but it certainly has been enormous. The general introduction of the locomotive between 1850 and 1870 instead of decreasing the number of common carriage and wagon makers increased the latter two hundred per cent. in those two decades.

The patents of American inventors, with some comparatively inconsiderable exceptions, have been wisely protected by our patent laws. The Patent Office, while not entirely free from the political spoils system, which at times has been a too unfortunate feature of our boasted republican form of government, does not shelter the corrupt official practices that it did formerly, or that obtain in certain other governmental departments.

It was but a necessary outcome that the various regulations to be observed in obtaining a patent ; the delays in passing upon applications, and, most important of all, the lawsuits to which claimants resorted to prove their alleged or just rights, should have caused to grow from the parent trunk another legal limb—commonly known as the patent lawyer. The average patent lawyer, I may amiably say, knows everything—past, present, and he will usually venture a radical plan of the future. The patent lawyer seems to be a necessity, for inventors, like poets, are proverbially incapable of getting "the best of the bargain" in respect of their mental wares. At all events, the patent lawyer is a distinct limb of the law to-day, and he generally has more than one string to his bow, if he be not too cautious, too prudent, in short, too honest. The patent lawyer seldom bothers with general practice. He baits his hooks for a special kind of fish, so to speak, and if he is not a bungler he generally lands some very fine and lucrative specimen. Of course, patent lawyers and patent agents confidentially emphasize their own worth and personal indispensability to anxious and promising clients, and often to impecunious inventors who, driven to desperation, entrust the profound secrets of their life's mental toil to some legal vampire in whom their confidence, they find to their sorrow, is misplaced. There are enough reputable and conscientious patent lawyers in this country, and inventors should have a care in selecting such men to perform the professional services which they are unable to do without.

The patent laws in some respects are very rigid, and the rules of practice of the United States Patent office require a long course of careful study, in order to be understood. Several desirable amendments of the existing patent laws have been proposed and it is hoped they will be enacted during the next Congress.

In conclusion, it may be remarked that the Patent Office, under intelligent and honest direction, will always take care of itself and that it will always leave a goodly balance to its credit in the treasury of the United States. The Patent Office to-day has an insufficient force for its multiform work and inadequate space. Like a few other bureaus of the public service, it is hampered and handicapped by the penny wise and pound foolish policy of usually neophyte yet obstinate statesmen who, neglecting the needs and requirements of the seat of the national government for facilitating the work and business of the departments, spend their time in urging retrenchment in really essential clerical expenditure, in advocating hide-bound local interests of their own, of their constituents or of others in which there is a "divvy," and in schemes tending to their personal aggrandizement and political distinction.

THE STEAM ENGINE IN MODERN CIVILIZATION.*

By Charles H. Loring, Past Pres. Am. Soc. Mec. Eng.

THE great historian who looks back a century hence upon the present era, with its numerous ramifications condensed by time into one focus, wherein the smallness of the field and the intensity of the light enables him to see plainly what we now only dimly discern, will point out that the great underlying cause of the wonderful progress made by mankind during the last hundred years was the steam engine.

And why should this particular machine have produced such amazing results?

Many other machines which preceded and accompanied its development are quite as ingenious mechanical combinations and involve quite as much knowledge and skill in their conception and construction as the steam engine, but the effects of which were, comparatively, both local and trivial, producing scarcely a ripple on the current of human affairs. Had they never been the world would have lost but little.

The answer is that the steam engine, with all its simplicity, is, what no other machine ever was, the creator of physical power, and this to so enormous an extent, at so small a cost, in so portable a form and with such convenience of application that it speedily revolutionized the economy of labor, and in so doing necessarily revolutionized all the conditions of man; for they all have been dominated by the labor question—the great bread-and-butter problem—since the primal curse was branded on the brow of the first man. It was to the relief of all mankind, in the struggle to find what to eat and wherewithal to be clad, that the immortal inventor of the steam engine gave to the world the finest solution of the problem it can ever hope to receive.

He builded wiser than he knew.

He retired contented with the profits of his invention and died without dreaming that he had placed on earth an infant Hercules whose club, with an ever-increasing might, would batter down the institutions of preceding ages; whose right arm, endowed with an ever-increasing power, would erect those of succeeding ages on foundations as different as strength differs from weakness, making possible the wonderful development of the man of the past into the man of the present.

All that man has he has obtained from the earth and is the direct product of physical labor, and the sum of his possessions is directly as the quantity of this labor expended. So long as this was manual labor his possibilities were limited by the number of men available.

Here was the barrier that confronted the man of the past, and until the advent of the steam engine progress was necessarily difficult and slow; and the little which was made in the centuries during which he had plodded upon earth was local, confined to few localities, and at the expense of progress elsewhere.

The civilizations of antiquity were limited to a few cities and were based upon slave labor, the slaves being drained from other places, which were thus doomed to deepening barbarism.

The limit of possible slavery was the limit of the ancient civilization. When

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the maximum number of slaves who could be advantageously supported on any particular territory was reached civilization stopped, except where direct robbery of other territory enabled it to maintain a fatuous existence ; and the limit here was soon reached, for this was a system of "killing the goose that laid the golden egg."

The disgrace of the ancient civilization was its utter want of humanity. Justice, benevolence and mercy held but little sway ; force, fraud and cruelty supplanted them. Nor could anything better be expected of an organization based on the worst system of slavery that ever shocked the sensibilities of man. As long as human slavery was the origin and support of civilization the latter had to be brutal, for the stream could not rise higher than its source. Such a civilization, after a rapid culmination, had to decay, and history, though vague, shows its lapse into a barbarism as dark as that from which it had emerged.

Modern civilization also has at its base a toiling slave, but one differing widely from his predecessor of the ancients. He is without nerves and he does not know fatigue. There is no intermission in his work, and he performs in a small compass more than the labor of nations of human slaves. He is not only vastly stronger but vastly cheaper than they. He works interminably, and he works at everything ; from the finest to the coarsest, he is equally applicable. He produces all things in such abundance, that man, relieved from the greater part of his servile toil, realizes for the first time his title of Lord of Creation. The products of all the great arts of our civilization, the use of cheap and rapid transportation on land and water, and of printing, density of population everywhere, the instruments of peace and war, the acquisition of knowledge of all kinds, are made the possibility and the possession of all by the labor of this obedient slave which we call steam engine. He is no product of nature, but purely the creation of art alone. He works for all alike and he works forever. His labor fills the earth and makes manifest the latent virtues and intelligence of our race. The immense ameliorations of modern society are due to the same cause ; and so great is the beneficence that, without irreverence, the steam engine may be truly called the material savior of man.

We who were born under this benign influence but vaguely appreciate its value and rarely recognize our obligations to it ; existing civilizations would be impossible without it, and if human ingenuity finds no substitute for it they will perish with it.

The steam engine is a machine which has been the prolific parent of other machines. It has caused the invention and construction of the immense plant of ingenious power tools employed in its own fabrication ; it has caused the improvement of metallurgy as a science and of the various methods of metal manufacture as an art ; it may be said to have created whole branches of important manufactures and to have been the occasion of the invention of the immense mass of highly diversified machinery by means of which these manufactures are practiced ; and, last and greatest, it has stimulated and directed the human intellect as nothing else ever has, and has done more to advance human nature to a higher plane than all which statesmen, generals, monarchs, philosophers, priests and artists have ever accomplished, in the vast interval which separates original man from the man of to-day. It has raised man from an animal to something approaching what a great intelligence should be, by simply placing in his hands a limitless physical power capable of application in every conceivable direction and to every conceivable purpose.

These words are no extravagant encomium ; they are a simple statement of momentous facts, which, however, the mass of mankind seems so little to understand and appreciate that I have ventured to give them record in a humble endeavor to prevent their being entirely overlooked and with a hope of their eventual recognition.

Contemporaneous historians have but scantily drawn attention to the immense influence exerted upon modern history by the steam engine. They follow in the same well-worn ruts, giving dubious descriptions of battles, names of monarchs and of statesmen, lists of decrees and laws, no end of political negotiations and intrigues and the whole array of puppets who seem to push the car of time while they are only flies upon its wheels. The real shaping cause of the march of modern events and of the great industrial progress of the times has but trivial recognition in the literature which pretends to account for what has happened or to predict what may ensue. One of the peculiarities of the genesis of the steam engine is that it seems to have been more in the nature of a creation than of an evolution ; for it was carried by its inventor, both as regards principles and practice, to a wonderful state of completeness. Very little has been added by his successors to his mechanical details or his various combinations of them. The invention seems to have nearly realized the birth of Pallas. The only modification in which he was not concerned is that of using the same steam in successive cylinders of increasing capacities, thus forming what may be termed, for the sake of distinction, the multiple cylinder engine as opposed to the single cylinder engine. The original multiple cylinder engine of Hornblower, brought out in 1781, and since known as the compound engine, and, by extension of the principle, as the triple expansion engine and the quadruple expansion engine, had thus a beginning almost coeval with the single cylinder engine of Watt. After much litigation it was declared to be an infringement on Watt's patents covering the use of steam expansively, and it passed out of use. It did not, in fact, give any economic gain over the single cylinder engine, as the pressure of the steam was the same in both and only a few pounds above the atmospheric pressure, limiting the measure of expansion for maximum economy to about one and a half times. With this low pressure of steam, and for the small powers used in those days, there was no mechanical difficulty in developing the whole power in one cylinder with all the economy possible. To obtain higher economy, higher pressure was a necessity, and pressure is solely a question of boilers. At that time the art of boiler-making was so inchoate that sufficient strength of generator could not be obtained for greater pressure, and the development of the steam-engine could not progress much, if any, faster than the art of boiler-making ; in fact, no one improvement in mechanics can advance much beyond the general front of what may be termed the industrial progress of the age. Aided by the improvement in the boiler-maker's art, the conspicuous advance which has been made with the steam engine is the direct result of the higher pressures of steam used.

The economic necessity for employing these higher pressures has brought into vogue again the multiple cylinder engine, which enables the steam to be used with a regimen not practicable with the single engine, and this regimen is attended with enormous economic gains. In the first place, what may be termed a "given quantity of pressure"—that is to say, the product of a given weight of steam by its pressure—is larger proportionately to the heat required to evaporate that given weight, the higher the pressure at which it is evaporated. The heat per pound of water vaporized from a given temperature, it is true, increases with the pressure, but the *quantity* of pressure produced under the greater pressures by a given quantity of heat increases in a higher ratio. The gain thus derived in the production of the pressure is very considerable.

Taking 50 pounds per square inch above the atmosphere as that usual with single engines of anything above small dimensions, and 150 pounds above the atmosphere as an easily worked pressure with multiple cylinder engines, the gain in heat by the higher pressure used is about one-twelfth ; a significant amount, but much less than what is additionally gained by the advantageous use of a greater expansion of the steam

made possible by the greater pressure. With the 50 pounds pressure, no gain is obtained by expanding the steam more than about three times, while with the 150 pounds pressure the expansion can be advantageously carried to about six times.

The result of both these economics is, that the multiple cylinder engine of the triple expansion kind produces the horse-power with about two-thirds the coal that the single cylinder engine does. Or, otherwise expressed, the single cylinder, under the given conditions, would require about fifty per cent. more fuel for a given power than the triple expansion engine. These are the mean figures for ordinary practice, which may be varied considerably for extreme and exceptional cases. The gain would be much greater than stated, were it not that the higher pressure is accompanied by higher temperature, and therefore the gases of combustion must leave the boiler at a correspondingly higher temperature. Thus the economic vaporization of the boiler is less with the 150 pounds pressure than with the 50 pounds. Obviously, too, the higher temperature is accompanied by greater heat radiations from all steam surfaces, and the higher pressure by greater steam leakages past the valves and the pistons of the cylinders.

If the original steam engine was the greatest boon mankind has ever received, an increase of its value by one-third over its best development should add proportionately to the benefaction; and such is the industrial effect of the modern steam engine in its most advanced stage. The engineering world has "improved upon its heritage and vastly bettered its instruction." But it cannot proceed much further on the same lines, for with much higher pressure than has been already used the temperature of the steam would be too great to permit the metals to work satisfactorily on each other, while all the deducting losses would increase in a more than corresponding ratio.

The consequences of decreasing the cost of power by so large a fraction as one-third are very far-reaching, far beyond the mere cheapening to that extent of products already manufactured; for it allows other manufacturers and other great works to be undertaken, which, with the reduced cost of power, become remunerative, but which at a higher cost would not have been undertaken. The benefits of cheapening power increase in a geometrical ratio: they radiate as from a centre.

This great improvement in the steam engine, adapting it to higher possibilities and greater radius of action, has carried with it all matters germane to it, and not the least among these is the enormous impetus and extension which it has given to mechanical science and art everywhere, making the engineer, by whatever name or title his specific work may designate him, the most potent factor in the world's progress, and "in the great work"—quoting from one of my eminent predecessors—"of emancipating mankind from the trammels of his animal nature."

Following as a natural sequence this recital of the potent influence of the steam engine upon man's social and physical conditions comes the question, Is it to continue as the great power-producing machine of the future? Can the inventive mind of man and his artful hand bring into being any other device as a substitute for it, that will do its work cheaper, better, and more handily?

To give answer to this is to say how it can be done, and as yet no one is ready with a reply. Without doubt, there are still "more things in heaven and earth than are dreamed of in our philosophy," but in the contemplation of a solution of this question, that already dreamed of is the limitation of our resource. Already we are beginning to avail ourselves of the enormous energy of water-power, now going to waste, through the convenience of electrical transmission and distribution, and the hand of the "Wizard" has drawn faint electrical energies direct from the combustion ot fuel.

The winds and the tides and the rays of the sun have locked up within themselves enormous stores of power, waiting, perhaps, for the ingenuity of man to un-

bind and convert them to his uses. But, when all shall have been realized which these as yet unused resources offer to man, when all man's present knowledge shall have ended in fruition, the steam-engine, from its portableness, its convenience of application, and its self-containedness, will still remain man's valued servant, the grandest conception of the human mind, the great conservator of the human race.

A NEW FORM OF CONDENSER.*

WE were recently invited by Professor Gamgee to witness the working of the apparatus which he has named the "Devaporator." A good deal has been said in some circles concerning this, and some facts relating to it may be of interest. The apparatus, as the name signifies, is intended to act as a condenser. Professor Gamgee is not, however, content to work on old lines, and to cause condensation by "transmission of the heat condition of water vapor to its environments not equally so conditioned." He works on new lines, and perhaps this explains the difference, or some of the difference, between his views of the results and those of some other people. Not all other people, for a few have experimented with his apparatus, and have thought it desirable that so important a subject should be investigated on a larger scale. This is, of course, also Professor Gamgee's view, but his reasons are not perhaps precisely the same as those of the experimenters, inasmuch as the latter may wish to remove small lingering doubts by working with larger apparatus. Those who have joined Professor Gamgee in so far as to provide the means of making these practical investigations into the scientific validity of conclusions generally held on heat and thermo-dynamics, may also like to experiment on a larger scale. They pay the piper and presumably get the time they want. People do differ on such matters, and that is the best reason we can offer for thinking that the apparatus we saw was amply large to exemplify the devaporative action. Less daring doubters of the truth of the accepted theories on these matters, and less courageous supporters of these doubts, have hesitated to attack them in an expensive way, but they have not had Professor Gamgee to lead them.

According to Professor Gamgee, the doctrine of latent heat is a fallacy, and that for the "automatic liquefaction of vapors there is no need of a cold body," that there is no necessity for a colder medium to dispel the heat of an engine exhaust, and that "the best condenser is one at or near the boiling point of water at atmospheric pressure." His contention is, "that the specific heat of exhaust steam being less than one-fourth that of water, it is impossible for steam to rise in temperature in a condenser except as the result of abnormal compression due to vicious mechanical arrangements." To those who do not understand the subject from Professor Gamgee's point of view, this last paragraph may appear to require disentanglement. But it does not. "From the earliest days of the doctrine of latent heat, distinguished dissentiments have pointed out its probable fallacy, but have failed experimentally to divert engineers from adhering to Black's Law."

* By permission of The Engineer, London.

For the purposes of discovery or diversion, Professor Gamgee has devised the arrangement of apparatus illustrated by the accompanying diagram. With this he has made experiments extending over months, and others have made experiments extending over days and nights. With it Professor Gamgee has endeavored to "forever dispel the mythical entity heat." The "devaporator" C is placed on an upper floor, and consists of five superposed pipes. The two upper pipes are tinned copper, 6 feet in length and 6 inches in diameter. The three lower pipes are 7 feet in length and 7 inches in diameter. The exhaust steam from an engine E on the ground floor is passed into this devaporator by a pipe as shown, which is fitted with a check valve, and enters the lower part of the upper pipe, into which it extends nearly to the position of the thermometer T, and is perforated. All the large pipes of the devaporator are wholly or partly filled with porcelain marbles, and the space not so occupied is filled with water. That steam which is not condensed in the upper pipe of the devaporator passes off from the centre and upper part by a tube, which enters the lower part of the pipe below. This method of connecting the seven large pipes of the devaporator is followed throughout, and the residual vapor and water pass off from the bottom by the stand-pipe SP, round a coil D, and thence down to the receiver R, fitted with a long gauge glass. In this receiver R, the water which comes over from the devaporator is collected, and may be returned to the boiler by means of the receiver *r*, to the top of which steam for that purpose may be admitted from the boiler. Any residual vapor which may escape from the devaporator or the receiver R,

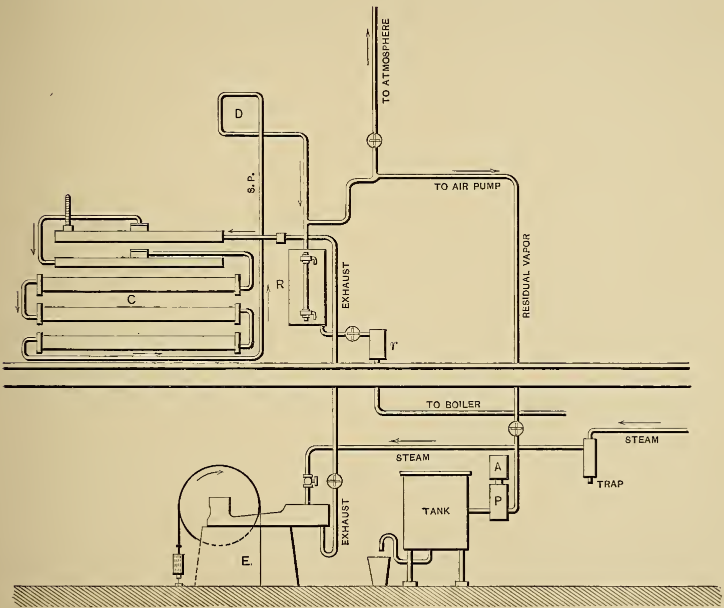
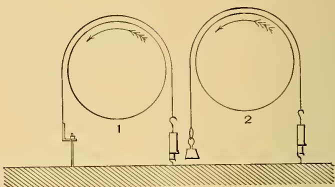


DIAGRAM REPRESENTATION OF THE DEVAPORATOR AND CONNECTIONS.

passes away through the pipe shown, which may be opened to the atmosphere, or it may convey it to the Westinghouse air pump A P, and thence to the tank near the engine. The engine has a cylinder 6 inches diameter and 8 inches stroke. It ran at about sixty-six revolutions per minute, against the resistance offered by a brake consisting of a hoop-iron loop with a few wood blocks, and with ends attached to a spring balance and to a bolt in the floor. The steam was provided by a vertical boiler at a pressure of about 58 lb., and was passed through a steam trap. This is perhaps a sufficient description of the apparatus, but it must be added that the devaporator was enclosed in a box filled with sawdust, and that the coil D was coated thickly with asbestos.

The apparatus had, we were informed, been working very satisfactorily, not only in Professor Gamgee's hands, but in those of others, and in response to an invitation to see it thus at work the writer visited Professor Gamgee's laboratory one morning and inspected it. After hearing a brief exposition of the inventor's theory of the apparatus, accompanied by all his admitted skill in the choice of impressive descriptive phraseology, that skill by which he so often masters the difficulties which arise from orthodox prejudices in his listener, it seemed that perhaps in this case the theory might be excusably postponed in favor of a little of the practice. An examination of the apparatus with this view showed that all the exhaust steam from the engine passed into the devaporator ; that the pressure in the top of the latter stood at a little over two pounds, that the pressure in the exhaust pipe near the engine was a little over three pounds, that a small quantity of water was being collected in the receiver R, that something like 100 square feet of pipe and tube surfaces were exposed and that some residual vapor was passing from the receiver R to the water-jacketed tank below. It was noticed that when one of the valves on this residual vapor pipe in the neighborhood of the air pump—not then at work—and tank was closed so that the residual vapor could not get away, the back pressure in the exhaust pipe rapidly rose to seven pound, and as this was increasing it was thought well to open the valve again. At this time none of the pipes were covered and the coil D not used. Being satisfied that all the steam from the engine was under these conditions going into the devaporator and as the morning call had occupied nearly an hour, time would not then permit of further inspection. As, however, there was obviously something to investigate



THE BRAKE—1 AS FOUND, 2 AS USED.

arrangements were made for a more complete examination of the apparatus another day. This day arrived and we found on entering the laboratory that, to test the theory, some one had had the whole devaporator covered in ; the coil D, which had in the meantime been inserted, was also coated. Not being concerned with the theory, but only a desire to know what became of the damp steam which was released from the engine, we arranged to measure the water passed into the boiler, the quantity caught at R and as a precaution the quantity of water from condensed residual vapor. This was done simply because it was desirable to know what proportion of the whole was represented by the residual vapor. The indicated and brake horse-power of the engine were taken also merely as checks. Before commencing we altered the brake, and instead of one end being kept down by a bolt, we kept it in place by a suspended weight. To this there was one objection, namely, that we had to deduct this weight from that indicated by the spring, making a difference of nearly 30 per cent. on the brake horse-

power previously read. This, of course, caused a disparity between our figures and those of previous experimenters, but this difficulty we have to accept, although we could not get in this way as high a mechanical efficiency from the engine as others had with the brake end connected to earth.

After running some time, no fresh supply of water having been put into the condenser, water began to collect in the receiver. It came over rapidly for a short time, although previously it had come in very slowly, and the back pressure near the engine reached 9 pounds. When the water increased to eight gallons in the receiver, five gallons were drawn off, and after this the rate decreased, and in two hours only three gallons were collected in the receiver R. Apparently the condenser had been emptied, or the stand-pipe S P and its more immediate connections had, for after this the back pressure fell to an average of 5.5 pounds, and it became necessary to pay more attention to the residual vapor pipe and tank below, the pipe to the atmosphere being closed. Here, as before explained, the residual vapor passed through the air pump valves, the air pump not being at work, and thence into the jacket of the vessel marked "tank," the inside of which was filled with cold water. From the bottom of this tank over sixteen gallons were taken—while only about three gallons were collected at R. During a total of two and a half hours thirty-two gallons of water were evaporated in the boiler. Of this sixteen and a quarter gallons were taken away in gallon measures from the residual vapor tank, the measure standing in a tub in which about two more gallons collected. This residual vapor was condensed by the cold water in the tank, and this water had to be renewed several times, because it reached a temperature as high as 192 deg. When this temperature was reached condensation was imperfect, and this "residual vapor" with the persistence characteristic of nuisances, would come away as steam, and not less than a quarter of a gallon can be allowed for this. A loss of considerably more than this took place at the steam trap. We have, then, as a statement the following quantities to account for the water evaporated and subsequently passed as wet or partly condensed exhaust steam from the engine into the devaporator.

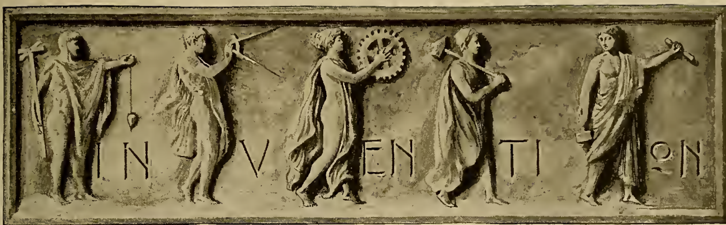
		Gals.
Water evaporated...........		32.00
Water and steam from steam trap........................	0.75	
Water drawn off from receiver	5.00	
Water collected in reservoir..	3.00	
Water collected by condensation of residual vapor from jacketed tank..............	18.5	
Total accounted for.........	27,25—	27.25
Left in devaporator and pipes, tank jacket, and waste, by difference.................		4.75
		32.00

Thus, it will be seen that if we leave out for the moment the five gallons condensed in the devaporator in warming it up, we have nearly all the feed-water accounted for by the water from the "residual vapor" condensed by the jacketed cold-water tank. In other words, about 80 per cent. may be accounted for by the residual vapor and that which would come from the pipes connected to the receiver R, the balance being accounted for by condensation in

heating up the devaporator, and by that remaining from the wet exhaust in the pipes. It may be mentioned that the indicated horse-power of the engine, as shown by diagrams like the annexed taken from one end of the cylinder, was 1.14 horse-power, and the brake horse-power 0.59 to 0.64, giving a mechanical efficiency of 52 to 56 per cent.

After this experiment the valve admitting the so-called residual vapor to the cold tank below was closed, and the valve allowing it to pass into the atmosphere was opened. When this was done the back pressure immediately fell to 2 pounds. In one hour 2.5 gallons were collected in the receiver R, most or all of which, that was not water as it left the engine, was condensed by the uncovered piping to the receiver, and to the atmosphere. The residual vapor when allowed to pass into the air might have been mistaken for a common exhaust, if it had not been called by another name. In the figures we have given we have made no pretense to minuteness, because where so much that is of importance is obvious the immaterial need not be considered.

Professor Gamgee's belief in the thing is shown by his allowing it to be covered in with non-conducting materials, but it is a pity that some of those who have experimented with the apparatus have failed to convince him that he does not condense steam by the devaporator. It would perhaps be idle to remind Professor Gamgee that although the specific heat of steam is but one-third that of water, the heat necessary to convert one pound of water into steam is a very large quantity, and that this heat will be given up on condensation, but that the condensation will not take place unless something is provided for taking up this heat, or is allowed to take it up. Or, more, perhaps, in Professor Gamgee's words, the heat condition of the steam will be unaffected by similar heat conditions in its environment.



NOTES ON NEW AND PATENTED INVENTIONS.—IV.

By John Richards, President of the Technical Society of the Pacific Coast and Editor of "Industry."

AN invention which has been described generally by the technical press, as well as being in use, is, perhaps, not a subject for description in these notes, but what may be called "departures" in the mechanism of steam engineering are not plentiful at this day, and when one is arrived at it deserves to be as widely noticed as possible.

The patent, which is No. 450,866, and was granted to E. K. Hill, April 27, 1891, is called an improvement in "valve mechanism for steam engines," and relates mainly to the combination of the induction and eduction valves within a perforated cylindrical shell called, in the specification, a "skeletonized plug," in the interior of which is formed the valve seats, these being of the multiported kind commonly called "gridiron," because of the bars and perforations. The cubic space occupied is reduced in cross section to small limits, as seen in the drawing, and the whole has the contour of a cylinder. Two of these are inserted, one at each end of the engine cylinder, in the manner shown in Fig. 3.

Fig. 1 is a perspective view of the mechanism complete, Fig. 2 is a partial section transverse to the ports and the flow of steam. Both the inlet and exhaust valves face one way, and the flow is indicated by arrows in Fig. 3.

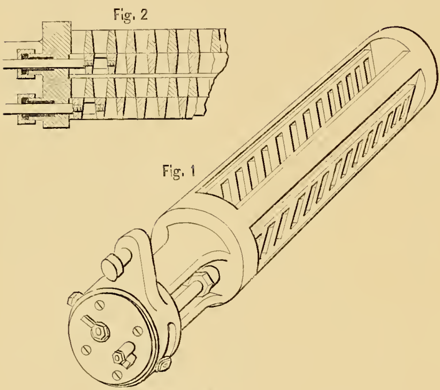
We are informed there have been some clumsy attempts to insert valves in this manner before, but not in a form to be considered as an anticipation of Mr. Hill's invention, which, as before remarked, constitutes a departure in engine construction in so far as any common practice that has preceded.

The clearances moderate, and the functions of the valves are complete, while the construction, condensed as it is, permits excessive port area, notwithstanding that both the inlet and exhaust valves are within the dimensions of the small containing cylinder or frame. The insertion and removal of these valve cases from the cylinder will involve a problem in the case of sea service, but not, we imagine, for land service where there is no exposure to salt.

The slide valves will meet with approval from the majority of engineers in this country at least, and is in the line of good, if not the best practice of our day, if we include in this remark the curved faces of oscillating valves, which are in effect the same thing as flat ones in respect to endurance and the somewhat obscure conditions that preserve valve faces.

The valve stems can be operated by various kinds of mechanism. That shown in Fig. 1, while it permits almost any kind of movement for the two valves, and releases variably the induction ones, is open to the charge of being "trappy," and we doubt if it remain long an integral part of Mr. Hill's valve mechanism. The movements are attained by spiral slots in the outer oscillating shell with pins or studs having rollers fitting in spiral or cam grooves. This involves "hair line contact" of bearing surfaces under considerable pressure, and is a serious infraction of the rules of bearings, also of direct strain, because of the overhang of the studs.

Perhaps the main feature of the invention is an economic one, in the fact that it reduces engine valves to a manufacture, and by a greater division of labor—system of labor it may be called—secures in this part of steam engines an excellence of fitting and quality not attainable when valves are made at the same time with engines. How this will be received by engine makers remains to be seen. There will be much prejudice against purchasing that part of engines which more than any other is an exponent of quality—their valves and the operating mechanism connected therewith. One maker, an eminent one, said recently in respect to the system, that "when he had no more to do with valves than bore a couple of holes in the cylinder, he would quit the business." This is, however, no argument that will last, and a preference on the part of buyers of engines would soon overcome the prejudice of makers.



FIGS. I AND 2

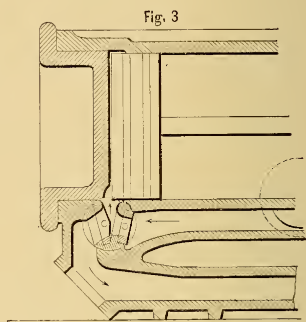


FIG 3.

It is not long since the same thing occurred in respect to engine governors. They were set off and became the subject of an independent and organized manufacture. For a time engine makers felt that this was an infraction of their rights, and a reflection on their skill, but sentiment is a weak power opposed to money, and when the cost of a governor became half as much, and the quality of its fitting twice as good, no one but the regular manufacturers thought of constructing governors.

There is every probability of Mr. Hill having hit upon the leading features of what may become a manufacture of engine valves, if such a manufacture is to be, that is, a complete self-contained set of valves to fit into two bored seats that may be prepared from standard measures, and without other dimensions of accuracy to be attained by engine makers.

Connecting rods seem also to be a detail that could become an article of

standard manufacture, because of the saving that could be effected by special tools not possible in a common machine works. Something has been done in this way for the smaller and cheaper kind of connecting rods, but the scheme does not seem to have succeeded well.

The Salford Rolling Mills, in England, began the manufacture of steel snap rings for piston packing, about fifteen years ago and, as we believe, have succeeded in founding a permanent trade. The rings were prepared by processes not commonly known, if known at all, outside the works. The section was parallel, with the inner edge rounded, and the bars had the appearance of being "drawn."

Some experiments with them in this country led to an opinion that their exterior or wearing surface was not true, and required grinding to produce a fit. Pumps, condensers, lubricating fittings, safety valves, and even pulleys and wheels, have left the engine shop for the manufactory, and now the distribution valves are threatened with a like fate.

It is an age of manufacture, and struggle for cheapness, or rather a struggle for existence amid competition, but the incentives and aims that govern this phase of modern industry are by no means so important a matter as the effect on use. This is the true economic measure of the methods of production. If by organized labor a steam-engine can be reduced one-half in cost, the increment of use would be much increased, perhaps in inverse proportion, but at any rate the effect on power-using industries would be a fact in proportion to which the change in engine-making would be an economic trifle. Babbage's Economy of Manufactures, written in 1832, should suggest to some one at this day the value and importance of a similar work, now that data is abundant. It is not a flattering view of our time and pretensions, but it seems no one is able, at this day, to discern a philosophy of manufacture as he did, or is capable of generalizations, then difficult, but now easy.

U. S. Patent No. 479,456, July 26, 1892.

O. B. PECK—CENTRIFUGAL ORE SEPARATOR.

The specification of this patent, as well as a good many others, indicates the very wide latitude permitted to inventors for setting forth their improvements. It is not easy to find perspicuous terms to describe inventions, and as specifications are commonly drawn by those not skilled in the technicalities involved, one need not wonder at some ambiguity, but certainly there are no reasons why the "arrangement" of specifications cannot follow some uniform plan.

In the first place the three primary clauses of a specification should conform to the heads, "relates to," "consists in (or of)" and "its objects are." This is the declaratory part, and in importance ranks next to the claims, because of disclosing the class nature and objects of the invention. The descriptive portions are to show the manner of applying or using the invention, and, in a sense, are unimportant compared to the declaration and claims. In the present case the specification begins with a description of the mechanism, referring however to a previous application, in which no doubt the nature of the invention is more fully set forth.

The purpose in referring to the present patent, is not to comment upon the substance of it or the mechanism involved, but to offer some suggestions on "selection" by centrifugal force. In all mechanical concentrating machines the separation or selection is performed by gravity; to some extent perhaps by adhesion due to the atomic structure of particles, and perhaps again to chemical affinity when canvas is employed and "doctored," but on the whole concentration is selection by gravity.

Luther Wagoner, C. E., of San Francisco, some years ago conducted a careful series of experiments on the precipitation of particles through water, and from his observations prepared formulæ, in which the element of surface was a principal factor. These experi-

ments were the subject of a paper read before the Technical Society of the Pacific Coast, and form, as far as known, the whole literature of the subject as applied to selecting processes. The main object was to throw some light upon the laws that govern the concentration of mineral particles, with what result cannot be stated, but there is this general fact pertaining to the whole matter, that gravity alone has been the active or settling force depended upon, and the gravity of particles becomes weaker as the particles are reduced and as the surface increases in respect to volume. This we know is true of water suspension, granite or quartz with specific gravity of 2.75 is carried as pulp or "slickens" for hundreds of miles in suspension, and fine dust of any material floats in the air when subdivision is carried far enough.

The suggestion is that if instead of gravity we apply the greater and controllable element of centrifugal force, can not selection or concentration be carried on more rapidly and completely?

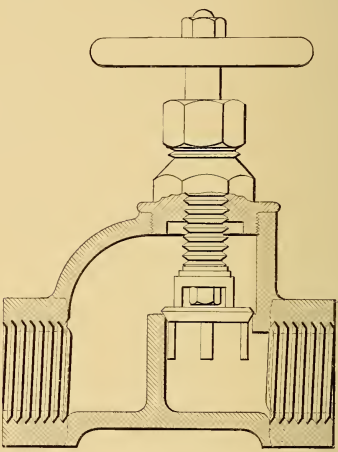
This may be the idea or scheme that lies at the bottom of the present invention, and if so it is worthy of careful consideration.

The drawings are too extensive and complicated for reproduction here and as at first intimated the specification is so drawn that the nature and objects of the invention are left to inference. Any one interested can study the patent and draw their own inferences.

A NEW STOP VALVE.

The section above shows a form of Stop Valve that may be less symmetrical than what we call a "Globe Valve," but is infinitely better in respect to functions. The commercial globe valve of our day is a contrivance that should be modified or disappear. The ducts are so obstructed and contracted that if a valve is put on a pipe where the flow can be observed, its obstruction will be a matter of astonishment. Some firms we know of have discarded the common form and provide an elongated body that affords a less obstructed flow, but the modification shown is better still, and more symmetrical than the spheroidal form. There are, of course, the same angles for flow, and the design could be much improved by filling in the corners, but they are free or "full way," as the makers call it, and the shell requires no more material than the spherical, or golden pattern, with a diaphragm in its axis.

The valves shown are made by a Nottingham firm in England, and the sooner it is adopted elsewhere the better. Stop cocks, as commonly made, are another example of bad practice. Twenty per cent. more metal would



A NEW STOP VALVE.

permit apertures for a flow equal to that of a corresponding pipe, but to save this moiety the corks are spoiled, and if a "free flow" is wanted the only way is to use a cock one size larger than the rated one, and bush it at the ends to receive a smaller pipe.

These things are mysteries of modern manufacture, not in the making so much as in the buying. No one thinks of demanding or even inquiring what the capacity of cocks and valves are, but in some other things they will contend for one or two per cent. of efficiency. For example they will purchase a steam engine and require a guaranty of steam consumption, then will purchase

a direct-acting steam pump incapable of performing at one-half the same efficiency and be contented, or will purchase a centrifugal pump stipulating that it shall perform a specific duty with a given amount of power, but will purchase a reciprocating pump, without question, that has half the efficiency of the centrifugal one. The vagaries are mainly a result of habit, if not, are inexplainable.

SCREW PROPELLERS—VARIOUS RECENT PATENTS.

Among the patents selected for notice in this section were some on screw propellers, but after a careful consideration of them they are laid aside, and instead will be given some unscientific remarks that may earn, or deserve, criticism if not refutation.

In a late patent there is proposed blades for propellers having a curved edge at the rear of the blades to, as the inventor says, "discharge the water in a direction opposite to the vessel's course. The following is quoted from the specification of the patent referred to:

"The rear edge is curved around, so as to be nearly tangent to the ship's course, so that the water will leave the blade of the wheel parallel to the ship's course, which is a desideratum, while with the old style blade the water leaves the wheel at an angle of about thirty degrees, and with an ordinary blade a large percentage of the force is expended in throwing the water out centrifugally, and a large part of the water passes over the ends of the blades, doing no useful work."

Mr. James Emerson, in his book on "Testing Water Wheels," speaks of fastening a ship to the dock and then driving the propeller to determine its thrust, and suggests a screw could be placed in a frame supporting a propeller, and the pull be measured by a brake or dynamometer. We might add other examples to show that the popular idea of a propeller is that it pushes the water away in a direction normal to the faces of the vanes, and the reaction from this diagonal thrust is the propelling power.

The lacking element, function, or condition in reasoning about screw propellers, is the forward progression into undisturbed water, and this element in propeller action is not only lacking in popular opinions on the subject, but also in mathematical treatment of the matter.

The inertia and immobility of the water through which a screw passes at various velocities of progression, is shown by a resistance to a flat surface when pushed through the water. Such resistance being approximately as the cube of the velocity. One square foot at ten feet per second, requiring a force of more than 100 pounds to propel it.

A vessel moving at 15 to 20 knots an hour, or 25 to 33 feet per second, would meet with a resistance of 600 to 1100 pounds per square foot, or any surface normal to the course. The same law applies to the blades of a propeller, so that at high speeds of progression a screw may be regarded as working in a nearly solid "nut," and without much radial, centrifugal or other disturbance of the water. We use the term "nut" because it completely, if not accurately, conveys an idea of the operation of a screw at high progressive speed, and it is only on this theory of inertia of the water that the efficiency of screw propellers can be accounted for.

With apologies to Professor Fitzgerald for this unscientific explanation, we think it contains the essence, so to speak, of propeller action, and disposes with the proposition of curved vanes to discharge water in any direction. In the investigation of the flight of birds there are some propositions respecting the forward movement into undisturbed air. The references are not at hand, but it is immaterial. Our contention is that the evolution of screw propellers as a history goes to show that the precise manner of their action is not known, and that the various forms proposed and made are based on theories that do not prove themselves in the results attained; also that the diversity of practice in designing propellers is a sufficient warrant for even empirical opin-

ions, here or elsewhere. We are not speaking of or doubting the truth of computation in respect to form, friction, or operation of screws, farther than to claim that the progress into undisturbed or solid water is the main fact of all, that this is the principal phenomenon of propeller action, and that at thirty to thirty-five feet a second, speeds now attained, a propeller becomes a veritable screw in a "nut" nearly immovable, and that centrifugal effect, angular velocities, and so on disappear, leaving little but skin friction to be dealt with in the case of all the diverse designs that have a true helical contour. From some authorities at hand we cull the following:

"The reaction of a stream of water reacted upon by any propelling instrument is the product of these factors, namely: The mass of a cubic foot of water—the number of cubic feet acted upon in a second—the velocity in feet per second impressed on the water by the propeller." (*Rankin.*)

From a formula based on the above assumption it shows that "the thrust varies as the velocity, and the lost work varies as the square of the velocity." Authority says:

"To assert that works with unusually little slip is to prove that it works with a large waste of power."

We might go on to quote a great number of propositions of the kind, including Mr. Froude's in his somewhat sweeping doubt of various assumed formulæ relating to propeller action.

Patent No. 481,773, August 30, 1892.

GEORGE S. STRONG—COMPOUND STEAM ENGINE.

This invention comprehends extensive features in the design and arrangement that are very fully set forth by drawings and very vaguely by the specification.

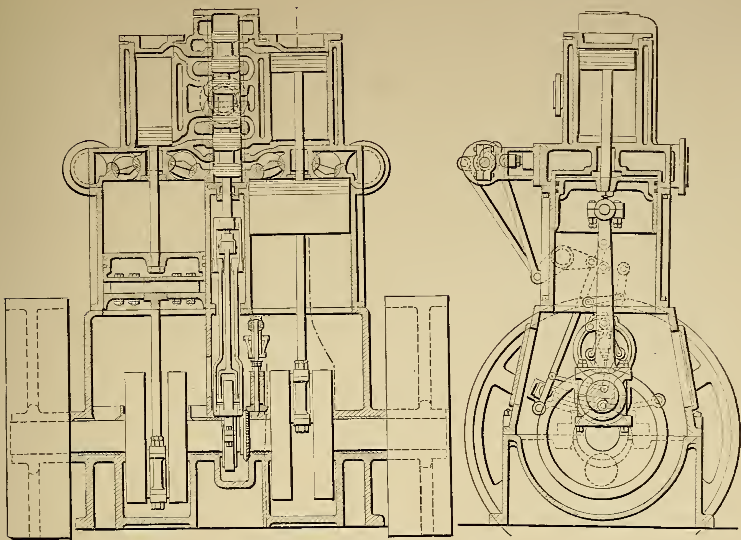
The invention relates to triple compound engines of the stationary type. The initial and intermediate cylinders are superimposed, as seen in the drawing, and two single acting low-pressure cylinders beneath, the latter performing the function of guides sustaining the diagonal thrust of the connecting rods, and constituting a section of the main framing.

Steam distribution for the first two cylinders is performed by a piston valve between them, and for the two low pressure cylinders by the gridiron slides shown at the top. The valve gearing is unique, consisting of what may be called a "floating link" and sliding block, controlled by a centrifugal governor, producing regulation by variable cut-off in the usual manner. The slide valves of the low-pressure cylinders have seats inserted in bored chambers, and are operated from a fixed point on the link, the whole valve system deriving movement from a single eccentric, as will be seen in the diagrams.

The external appearance of the engine is especially symmetrical, as have been various designs of Mr. Strong's, and the whole seems to have been the result of an effort to put into condensed and simple form the various characteristic features of modern high-speed engines in harmonious relation.

Without attempting an analysis of the valve movements, which at this day can be assumed as correct, when coming from the hands of a competent steam engineer, the present engine has the following features of note. The double low-pressure cylinders and direct connection to the pistons; reducing the height or length of the engine to that of a side by side or single cylinder one; the enclosure of all running parts, including the governor links and first movers of the valve gearing. All valve motions derived from a single eccentric. A built up frame consisting of a sub-base crank chamber, low pressure cylinders, then the initial and intermediate cylinders, the whole tapering upward in the order of their respective cubic dimensions.

To trace back the evolution of steam engine arrangement and framing, taking the Westinghouse and Willan engines of 1880, and succeeding types of the single-acting type, down to the present time; the steeple-framed, direct connected marine engines of 1870 and



STRONG'S COMPOUND STEAM ENGINE.

since, with the many intermediate designs of stationary engines, verging more or less toward the two types named, one can see a kind of order and sequence toward an ideal vertical steam engine that is on its way, but doubtless far from completion at this time.

The multiple cylinder arrangement, and the high pressures concomitant with the increased expansion, have disturbed a good deal the gradual evolution of design. High speed has at the same time been added, increasing bearing surfaces, altering the means of lubrication, and the material for bearings. It has been a struggle toward the ideal, with formidable obstacles arising at every turn, such as could not be turned aside, but must be absorbed or eradicated permanently.

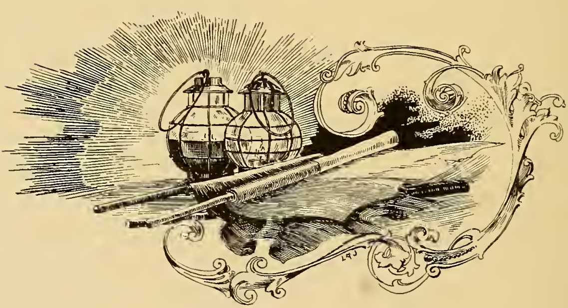
This race and struggle toward the ideal engine could never have gone on as it has without the powerful incentive of steam economy, or money saving, it may be called, constantly increasing in importance by wider use. The gain in this respect has outstripped even the endless modification in constructive features, or has paid the cost of experiments as we went along. Fairly stated, and with respect to steam power as a whole, the economy of fuel has been going on at the rate of one pound of coal per horse-power for every five years of effort, and has now nearly reached the limitations set up by thermal laws, qualified by the possibilities of construction and maintenance, such as present knowledge permits.

Common reasoning in these things measures the future by the past, skilled reasoning does not, and to claim that the future is to see changes in the design and operation of steam engines go on as in the past is not a rational assumption, nor is it in accordance with familiar precedents. For example, the Jonval and Fourneyron turbine water wheels were introduced in this country about thirty and forty years ago respectively, and among the very first wheels set at work, those at Lowell and Philadelphia for example, are as good wheels as can be made now, not only in respect to efficiency, but in construction as well.

It is true the element dealt with was

tangible, ponderable and amenable to physical laws tolerably well understood for a century past; not like heat surrounded by mystery, intangible, invisible, and with newly discovered relations; but making allowance for all this, there is no doubt that steam engines are fast approaching a state at the present day that may be compared with that of water wheels in 1850 and 1860, and the present engine, whether many or a few of its characteristics survive in future practice, seems another step toward the ideal.

The internal-combustion class of engines, which, according to many conjectures, are to supplant the steam engine, have now some advantage in fuel comsumption, or fuel cost. Gas or petroleum burned within a cylinder is apparently a cheaper source of power, because the method is novel, and the value of heat-producing fuel has not had time to adjust itself on the basis of its "energy," as a motive element. Even power itself is far from having a settled commercial value such as we may reasonably expect it to have in the near future, and of course the elements of its production must vary more still, but when the value of carbonaceous substances is determined by their heat, then the internal combustion engine, as now made, will be at some disadvantage with its high temperature, sudden impulse, and consequent irregular strains.



MACHINE SHOP CONSTRUCTION.*

By Prof. John E. Sweet.

WHILE there may be but little of definite importance found in the following, except such as derived from experience obtained in designing, building, and operating in a single structure, the paper is based upon the above broad title in the hope that those of the posted members who have builded "better (or worse) than they knew" will enrich the discussion with ideas; and while the writer may not let in much light, he hopes to present a clear story, and trusts that in opening the door for debate, no one will have any fears of getting floored in the discussion, or seek shelter from hostile criticism under a Burnside tile.

When the size and form of a shop have to conform to the lot upon which it is located, then it will depend upon the genius of the designer for its success; but if the designer simply builds the building as large as the lot, and leaves the arrangement for future study or fate, it is liable to be a failure. An architect, unless he be one who has made a special study of it, is liable to do more harm than good. The plan should be studied to arrange things in the most convenient form, the doors and windows where wanted, and then, if there is a desire to have it look well, as there should be, the architect, if he has the genius, can make it look right without moving a window or adding useless appendages.

If one has an open field at his command, an equal opportuuity is open to study out the best plan. Building shops by the mile, and cutting them off in so many hundred-feet pieces, and setting them down like a gridiron, a Greek cross, or a gavel fork, may not be just the best thing to do.

There is this, it is true, that one can get them only about so dark if limited to a moderate width and held to a goodly half-useless space between the branches. Ventilation is good, but it makes long distances to travel between the different departments, and that is very bad when a place is so small that one man has more than one department under his control. In many respects the weaving-shed plan—that is, a one-story structure in sections, separately roofed, with the north sloping side of glass—has advantages. As to ventilation, in its simplest form it may be inferior, but the ventilation is easily controlled when the problem is once fairly attacked.

Common and fashionable as is the salt-block construction—that is, a central high section with a gallery on either side—this form, when used in a shop so small that one foreman has control of all the machinery, has this disadvantage, that he has to "see-saw" across from side to side, worming his way through the erecting section, whereas, with the erecting floor at one side, the machine tools are concentrated. With a small shop, too, the climbing up and down stairs is not only a nuisance, but absolutely costly. Things can be moved in an elevator very cheaply, but carting, loading, unloading, and carting again spoils the economy. It is doubtful if there is any saving in two or more storied shops, except in real estate, and when as much ground has to be left idle to get light as is covered by buildings, then the saving in real estate is small, unless the buildings are more than two stories in height.

The advantage of the one-story weaving-shed roof plan is that the building can be extended to any length in either direction, and to any width in one direc-

* Read before American Society of Mechanical Engineers.

tion, without interference with light, with advantage in heating, and with the advantage of having everything on one floor, and that floor a solid one. The trouble apprehended from ice, snow and water has no foundation in fact, and if dealt with in the way described later, need not give one a moment's anxiety.

The section for traveling cranes can be of any height and width, without interfering with the weaving-shed struc-

under the different parts should be in proportion to their loads, and the centre of the foundation should be directly under the centre of pressure. Or, to emphasize the ideas, it is just as detrimental to put too much foundation under the light parts of a building as too little under a heavy one, and worse to have a load rest on one side of a wide foundation than on the centre of a too narrow one.

In the locality where the writer re-

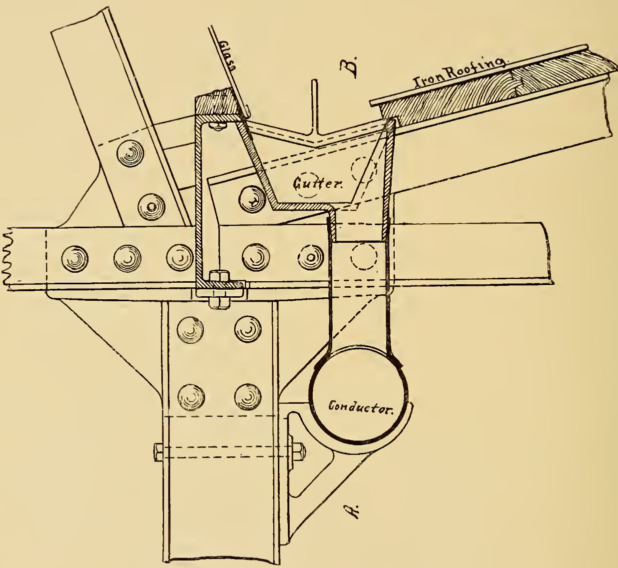


FIG. 161.

ture or light, by placing it on the south side.

While there is getting to be some really genuine permanent foundation building done in this country, it is mostly confined to the larger commercial cities, and has not as yet found its way into the workshops or small towns.

The principles are easy to understand. If the earth throughout the entire structure has equal sustaining power, then the area of the foundation

sides it is as impossible to get these simple rules into builders' heads as it is impossible to get them executed, or a decent brick wall built. The foundations stand when built directly at variance with right, and brick walls stay up when they ought to tumble over, seeming to depend more on force of habit than the strength of the mortar.

Machine-shop floors are a problem, and while those made of dirt, like some of the French ones, seem to last the longest, they are hardly satisfactory;

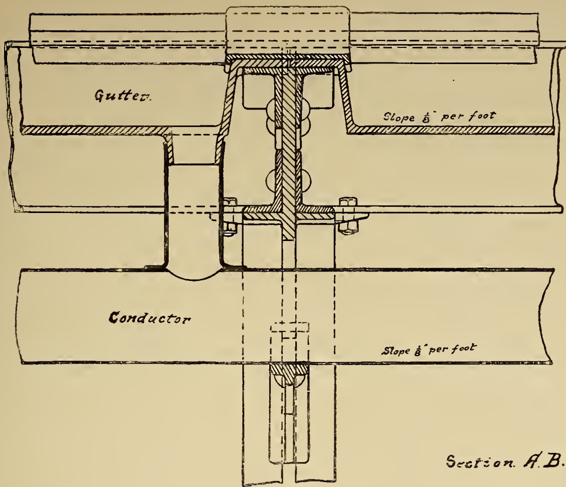


FIG. 162.

neither are the English brick floors. The following, used in the works of the Straight Line Engine Co., is believed to be better than most of the floors heretofore constructed. The earth was excavated to a depth of 27 inches below the floor line, and rolled with a heavy roller, the soft places filled, and again rolled and levelled. Building-stones of the cheapest sort—that is, stone too poor for foundation walls—were dumped on the ground, and men set to sorting the largest pieces and closely packing them on the ground ; a strip of two or three feet of this work was kept in advance of the other filling, so as to insure its solid character. Upon this was a layer of the smaller stone, then broken stone, coarse gravel, fine gravel, and, lastly, sand. There is no other possible way in which each grade can be made to retain its place, except by reversing the process and putting the larger above the smaller. If mixed indiscriminately, the fine will work to the bottom and the coarse come to the top. By following the plan given, a solid foundation is secured, upon which is placed nothing but 2-inch hemlock plank running one way, with a 1-inch planed and jointed, but not matched, floor running the other way. The advantage of the thin top is that when there is a hole worn through, it is but an inch deep at the most, and the plain strips of uniform width make it easy to repair. This makes a floor on which anything can be set anywhere, except the largest of the machine tools requiring separate foundations.

Some accounts of the English practice give 16 feet as the width of spans or bays, but in the works above mentioned 32 feet is used, 8 feet being the unit upon which the building is constructed. In a more extended plant, 10 or 12 feet would be proper. The posts are 8 feet or 16 feet between centres, and all the roof trusses 8 feet. The roof is simply 1½-inch pine plank, 19 feet long, planed and matched, planed side down, nailed to thin strips of basswood riveted between the two angle-irons which form the rafters, covered with ribbed, not corrugated, iron ; and the flat roof over the traveling-crane section is the same, except the gravel roof.

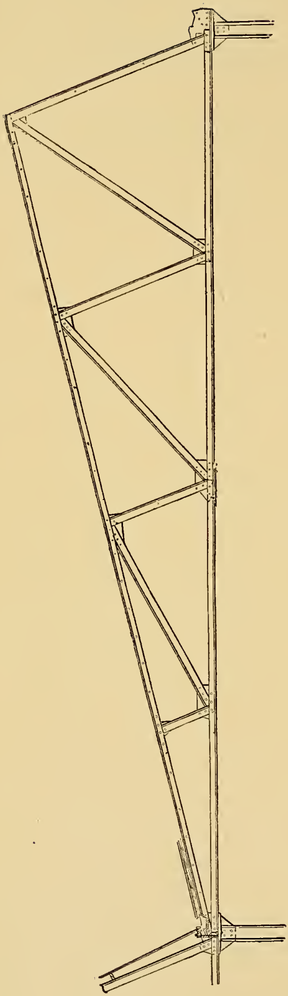


FIG. 163.

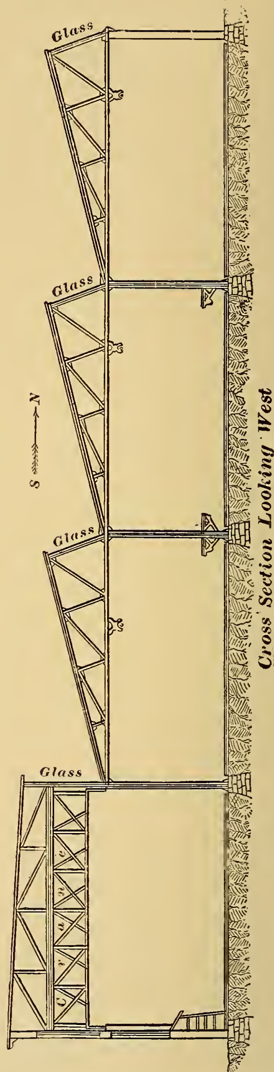


FIG. 165.

In the construction of the posts and roof, by making each member of two pieces ⅝ or ¾ inch apart, between which bolts can be passed, a convenient means is at hand to fasten anything anywhere.

The iron structure is more expensive than wood, but lighter, exempt from fire, and, with the provision for bolt attachment above referred to, more convenient.

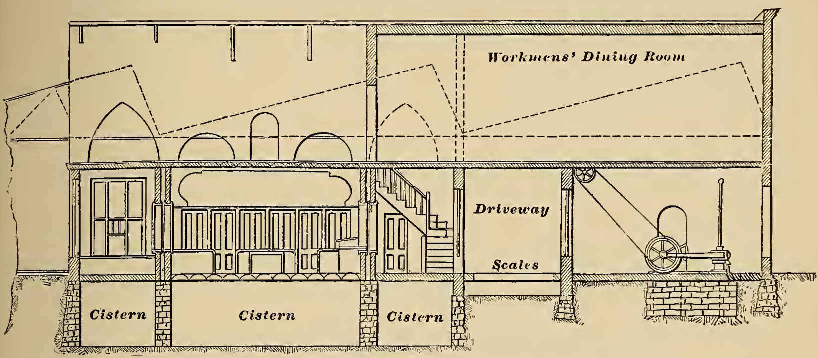
The trusses are strong enough to hold three or four tons besides the roof, so that any pieces of machinery or work which are liable to be handled can be raised by tackle attached to the trusses in whatever part of the place they may be.

The question of snow, which seems to be the bugbear to every one first thinking of the weaving-shed roof, is one requiring hardly a second thought. Making the gutter of cast-iron, as shown in Figs. 161 and 162, or any convenient shape, and putting it inside the building, with the heating pipes adjacent, is all which is required. Keeping the gutters clean is all there is to it, and snow and ice will thaw sooner in cast-iron than on the wood planking when the heat comes from the lower side.

Eight feet between centres would seem to be too near together for posts, but by making benches 12 feet long, supported by two posts, leaving 4 feet spaces between the ends of the benches, the apparent objection vanishes where the bays are as wide as 32 feet.

In a building for large work, with 10 feet between trusses, the bays could easily be 40 or more feet, with 8 feet of glass on the northern slope.

The geometry of the roof is very simple: simply dividing the lower chord into four equal parts, and the rafter into four equal parts, and joining the points with the struts and braces (Fig. 163). While economy of material would dictate iron of different section and weight, to save bother we used all alike, and as the accidental loads are unknown quantities placed in unknown positions, perhaps that was as well as applied high science.



Section through Office and Engine Room.

FIG. 164.

The accompanying cuts are self-explanatory (Figs. 165, 166).

In the weaving-shed system of lighting the annual cost for repairs of broken glass is practically *nil*, and in this connection the writer volunteers to say that he believes an erroneous idea is pretty universally prevalent in regard to the most economical size for lights of glass for shop-lighting. The theory is that the small-size lights for various reasons are the most economical. But after a

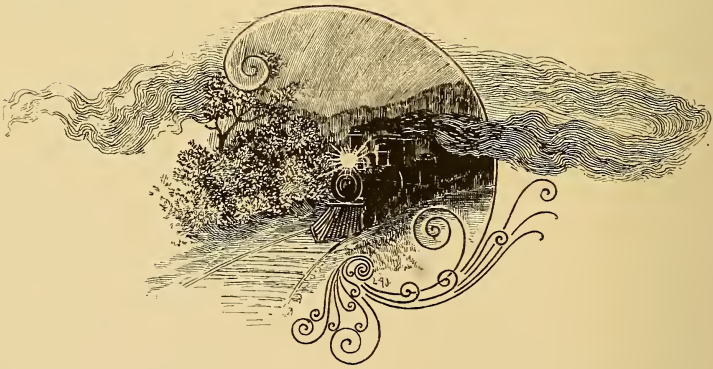
long observation, the evidence to me is conclusive that the larger the lights the less the cost for repairs. Large lights stand far more punishment, and the workmen have some respect for a light of glass which costs a dollar, but none whatever for 10 x 15 glass. Whether these are the reasons or not the fact remains that where in one part of our works the annual breakage of 10 x 15 glass does not fall below 100, there is another part where the large lights were equally exposed, and there was but a single light broken in two years.

The writer's observations in this direction have not been confined to a single case, and it will be to the interest of those contemplating new buildings or changes to investigate this subject.

In the works mentioned, the main office is a fireproof vault in effect. Drawings, books, and valuable papers are thus protected by simply closing the fireproof doors, which are self-closing, in case of fire, if neglected. For small works this is better than a separate building, as it concentrates the supervision. Low partitions, or simply a railing, separate the pattern shop from testing floor and main shop, instead of closed rooms, with a great advantage (Fig. 164).

It leaves the whole place subject to observation, and the men work nearer ten hours a day when paid for ten hours, and are just as happy at night as if two hours out of the ten had been spent in visiting.

While visitors are always welcome, it is more than probable that we have less visiting than other shops of the same size.



SOME INTERESTING MACHINES.

By Geo. L. Clark.

THE machine illustrated on the next page for drilling square, or polygonal and triangular holes, all of which are made with sharp edges in metal, stone or wood, is among the recent inventions of interest. The engraving, which shows the details quite plainly, is published by permission of The London Engineer. The drill spindle is swelled about its centre, so as to form a kind of universal joint or spherical bearing, which permits a certain amount of oscillation in addition to the rotation. This oscillation, or lateral travel, is determined and limited by a series of flat dies or templates inserted horizontally in a fixed ring at the top of the machine, and clamped by set screws in the positions suitable for producing the shape of hole required, including one of star and even D form. The drill or cutter has a section of segmental form, and is set so that its cutting corner is in the centre line of the spindle. The angle of this corner must be a little smaller than half the smallest angle of any given hole, in order to permit of the drill clearing easily. The dies or templates, in the case of a symmetrical hole, are first placed in position roughly ; and for this purpose they are provided with longitudinal slots, through which the set screws pass. The dies also have diagonal slots through which pass pins set in a second ring, that may be slightly turned on its imaginary axis by a screw, thus bringing the dies nearer to or farther from the centre for nice adjustment to the size of hole required.

The engraving shows a pedal arrangement for giving the feed ; but for very accurate work, and indeed generally, it is found preferable to feed the tool down by hand. The front of the frame forms a V-slide, on which a saddle carrying the drill head is fitted. The saddle is balanced by a counterweight inside the frame, and can be raised or lowered by a small rack and pinion at the back. The pinion shaft is operated by a hand-wheel at the side of the frame, and is also provided with a fine cut worm wheel. This machine is constructed by the Square Drilling Machine Company, London.

Recent developments in machine tool construction brings to notice a tool just designed and brought out by the Niles Tool Works Company, of Hamilton, Ohio.

The machine was designed for cutting off large pipe, ranging from thirty to forty-eight inches in diameter, and for that purpose a very large, massive and powerful tool was necessary. The driving mechanism of the face plate and the movement of the carriage on the bed are controlled by the operator standing in one position, by the use of clutches handily arranged, as shown in the illustration. The cutting is done by two tools revolving around the pipe, the tools being held in the tool-heads, the latter being bolted to the faceplate, and the pipe is clamped in two V-form chucks, as shown, adaptable to the various sizes of the pipe. All gears are cut from the solid. The spindles, shaft and lead screw of steel, of ample diameters for the duty of the lathe. The machine shown is engine-driven, and for large pipe. The tool can be constructed for pipe of any sizes and

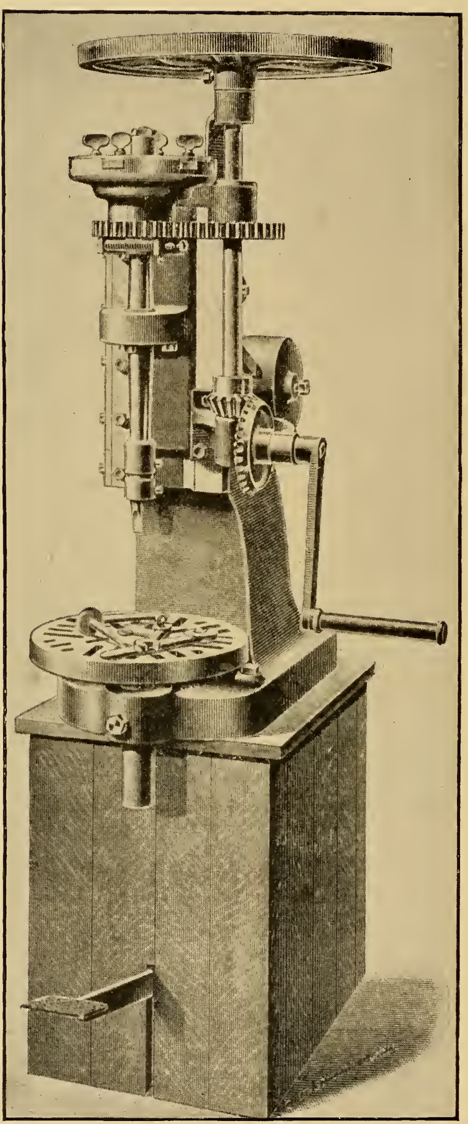


FIG. 1.—MACHINE FOR BORING SQUARE HOLES.

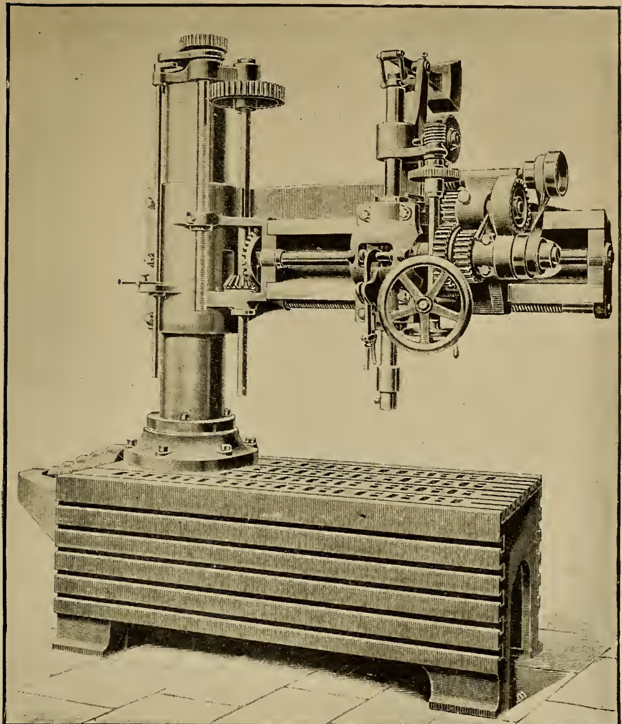


FIG. 3.—A RADIAL DRILL.

lengths, and either belt or engine-driven, to suit the requirements.

A drilling machine of special design, which is illustrated in figure 2, constructed at the Britannia Works, Colchester, England, was recently described in Engineering, of London. It has a heavy foundation table of box form, planed, with planed T slots on the top face and on each side. Mounted on the table is a turned column, carrying within it the vertical driving shaft geared up with mitre gearing. Around the column there revolves a strong external column, accurately fitting it. The latter carries a radial arm made to rise and fall by self-acting arrangement by power. Fitted to the arm is a saddle carrying the counterweighted drilling spindle, which can be driven by single or double gear. The spindle is fitted with self-acting feed motion by rack and pinion, with an engaging clutch. The horizontal driving shaft fitted into the foundation bed carries a driving cone having five speeds, giving, with the double gear, ten changes of speed. The spur gearing is machine cut out of the solid, the smaller gears cut out of mild steel. The dimensions are as follows: Foundation bed, six feet four inches long by three feet two inches wide by two feet six inches high ; the external rotating

FIG. 2.—MACHINE FOR CUTTING LARGE PIPE.

column, twelve inches in diameter; length of arm, six feet four inches; vertical traverse of arm, two feet four inches; drills through a maximum radius of five feet; drills out of the solid up to two inches in diameter; bores up to nine inches in diameter and twelve inches deep; the steel spindle is two and one-half inches in diameter; driving shafts, two and one-half inches in diameter; bevel gearing, one and one-quarter inch pitch; machine-cut spur gearing, one inch pitch; speed cone, five speeds three and one-half inches wide; largest speed, seventeen inches in diameter; smallest, six inches in diameter; approximate weight, three and three-quarter tons.

The Egan Company of Cincinnati, Ohio, have recently produced an automatic gauge lathe, designed for extra large work. It turns stock up to six inches in diameter and up to forty-two inches long. Heretofore it has been considered impossible to turn stock six inches in diameter on an automatic gauge lathe. Work of the above diameter has always been turned by hand and at a great cost. The bed is made in one solid piece, of extra width, planed true, with "V's" for the sliding rest to run back and forth on, and a centre bar on which is attached the form or pattern for roughing out the stock ready for the back knife to make the finishing cut. The head stock is furnished with journal boxes of extra length lined with genuine babbitt metal, perfectly rigid to receive the large spindle, and on this spindle is a cone pulley with two speeds and an extra speed to drive the feed, connecting a

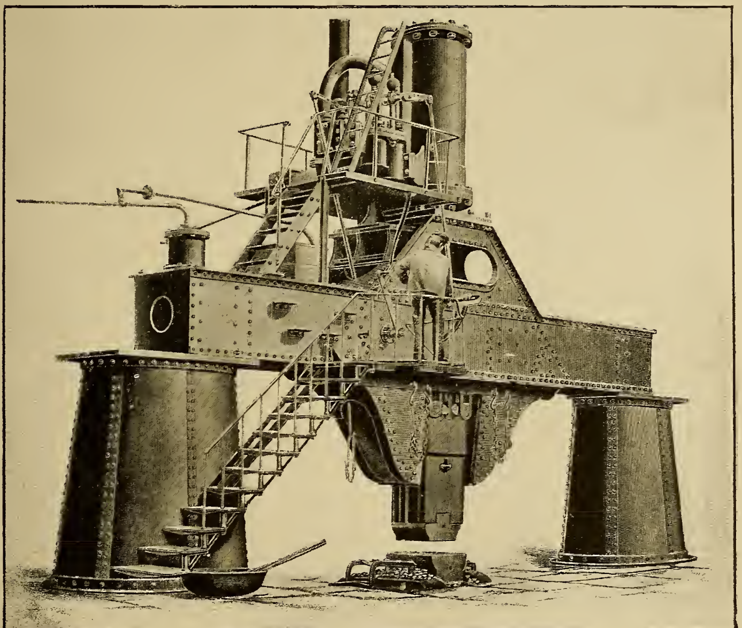


FIG. 5—A STEAM HAMMER AT ESSEN, GERMANY.

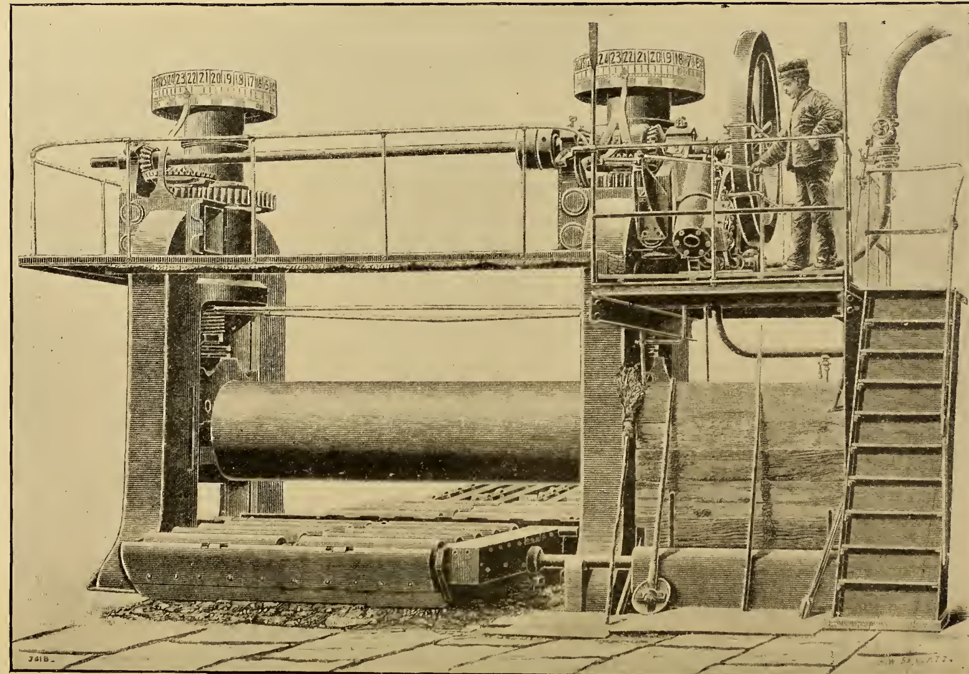


FIG. 4.—A ROLLING MILL AT ESSEN, GERMANY.

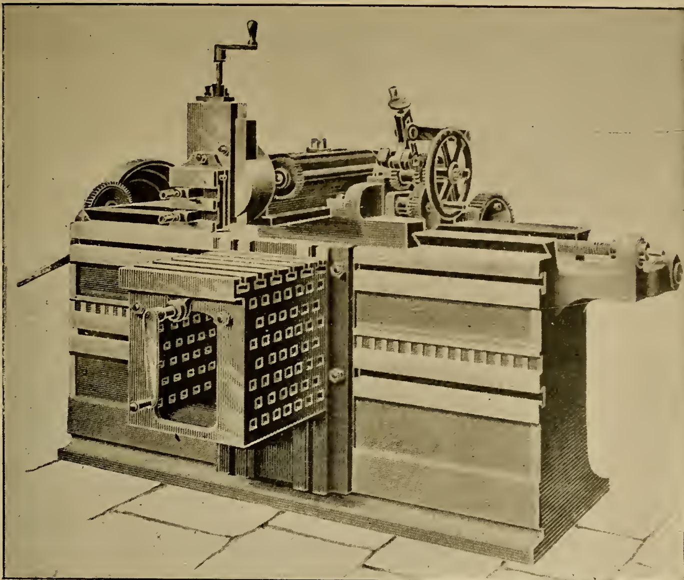


FIG. 6.—SHAPING MACHINE.

short countershaft below, which is part of the machine. The tail stock is made on an improved plan, and is provided with gears and screws so as to apply the power as near the centre as it is possible to get, bringing same exactly in line with the driving centre. The sliding carriage is made to move back and forth along the ways by a screw, operated by a cone pulley from the feed shaft below. Provision is made for opening and closing the nut automatically for moving the carriage back and forth. It is also fittted up with two adjustable arms, one for the roughing stock to fit the thimble-plate and the others for roughing out the moulded part of the stock, ready for the back knives to make their cut. The back knife attachment is connected to the bed, supported at the top and held perfectly rigid. The bar which carries the back knives is made to slide up and down in planed ways, countered by weights and controlled by the sliding rest. By this arrangement, the back knives are made to act on the stock close to the thimble-plate or support, thereby allowing the back knives to cut perfectly smooth and free. The back knives are attached to the bar and adjust on the frame and can be regulated to suit the different diameters to be turned.

The shaping machine illustrated on this page is constructed by Messrs. Lister & Company,. of Keighley, England, and contains some new features. The stroke of the machine is fourteen inches, and the bed is six feet six inches long, whilst the weight is sixty-eight hundred weight. The ram is four feet six inches long, and works in a shell thirty-four inches long. A four-speed cone pulley is provided for driving the machine, the longest cone being twenty-four inches in diameter and wide enough for a three and one-half inch belt. In addition to the self-acting motions com-

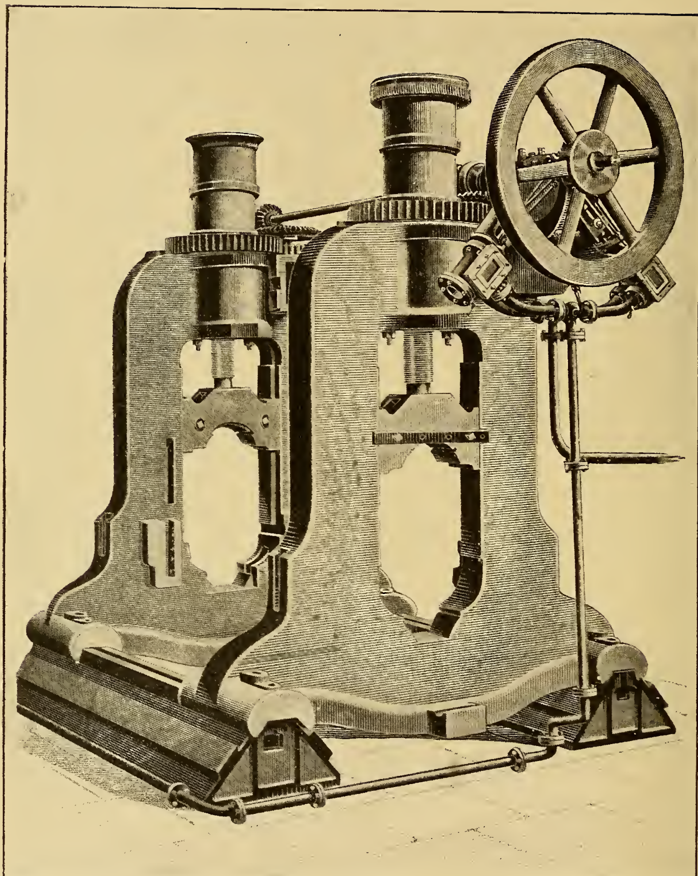


FIG. 7.—PART OF ROLLING MILL AT ESSEN, GERMANY.

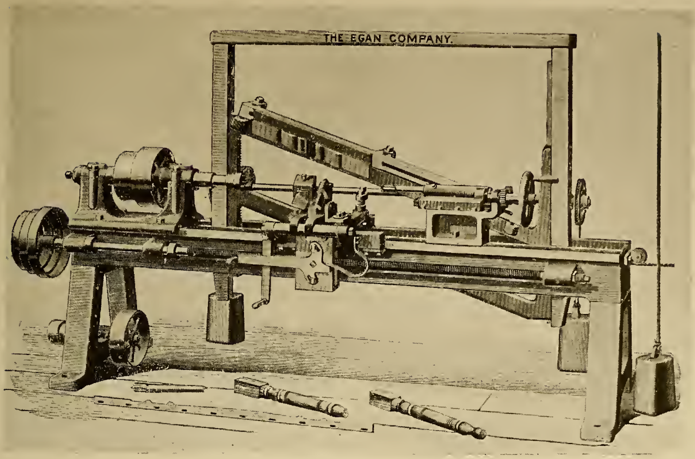


FIG. 8.—AUTOMATIC GAUGE LATHE.

mon in machines of this class, the vertical slide is provided with an automatic feed, on the same principle as the vertical feed often fitted to the tool-box of heavy planing machines. This feed is worked from a compound lever on the driving wheel, and is adjustable whilst the machine is running, by means of a slotted lever and a block worked in it by a small hand-wheel. The machine is fitted with a quick traversing motion by power along its feed, in addition to the ordinary feed, so that the tool can very rapidly be brought up to its work without waste of time. This motion is operated by means of a friction gear, consisting of leather-covered discs, and can be started, stopped, or reversed almost instantaneously. The usual hand adjustments are also provided. The table is formed into a receptacle for tools, spanners, etc.

In Germany, as a rule, wrought iron is still used on a large scale for boiler-making, and Schulz, Knaudt Company, of Essen, have always striven to bring the manufacture of wrought-iron plates to its highest perfection. They invariably make many tests to control the quality of their material; in the last three months of 1890 about 3000 tests were executed in their testing-house with the results shown by the following schedule:

	Tensile Strain in Tons per Square Inch.		Elongation in 8 In.	
	Lengthwise.	Across Fibre.	Lengthwise. per cent.	Across Fibre. per cent.
1st quality..	23	23	23	20
2d " ..	23	22	22	17
3d " ..	22	21	19	13

The slabs and ingots are reheated in six Siemens' gas furnaces and four other furnaces with solid fuel firing. The forging of the iron slabs is done by two steam hammers of five tons each.

The illustration of one of their steam hammers and parts of their rolling mill are printed on pages 233, 234 and 236. Fig. 5 shows that the housing of the hammers consists of two wrought-iron pillars with box-section girder; this construction was first applied by Messrs. Schulz and Knaudt in 1862.

The principal rolling mill is driven by a reversing engine, which acts upon the rollers by means of toothed wheels geared 1 : 3. Each of the two cylinders is thirty-six inches in diameter with fifty-four inch stroke. There are three pairs of housings, and the length of rollers amounts to eighty-four inches,

115 inches, and 138 inches respectively. The latter is fitted with a table with live rollers; the whole arrangement looks strong, as appears from the engraving. Fig. 4 represents the housing of the 115 inch roller. The setting of all top rollers is effected by a little two-cylinder engine fastened to the housing.

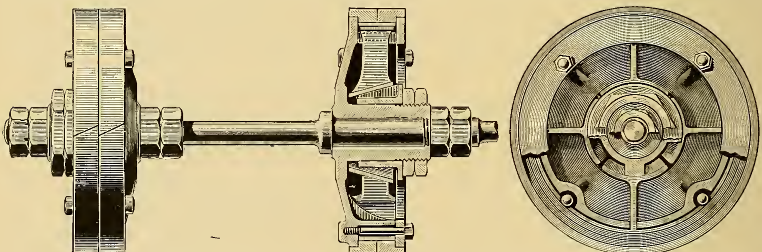
A vertical engine of forty-three inches in diameter and forty-six inches stroke drives a pair of rolls of eighty-four inches length; these rolls are in direct connection with the engine shaft. They are only designed for the manufacture of smaller plates. The engine makes about eighty revolutions per minute, and the whole machinery is not based upon the three-high roll system, but consists of two rollers only, having no reversing capacity. The illustrations are reprinted by permission of Engineering, of London.

AN ADJUSTABLE PISTON VALVE.

The engraving on this page shows the form of piston valve used in the "Ideal" engines, made by the Harrisburg Foundry and Machine Works. It has been patented by M. E. Hershey, the general superintendent of the company.

The primary object of this construcion is to provide a piston valve which shall be capable of rigid adjustment to compensate for wear, whereby the adjustment is maintained throughout the stroke of the valve and while subjected to peripheral pressure in passing over the ports. A further object is to provide a valve of this character which, when the parts are cooled, will contract and prevent sticking or injury to wearing surfaces, as for instance when the engine is started after period of rest.

To accomplish this purpose an adjustable sectional spider is introduced, as shown in the cut, of composition metal or brass, having greater range of expansion than the metal in valve proper or its seat. Live steam is admitted between the valve disks and the adjustment made when hot, the normal working condition. When steam is stopped off from the valve and the parts cool, the sectional brass spider contracts to a greater extent than the surrounding metals and releases the packing rings, leaving them entirely free in their seats. When steam is admitted, the expansion of the spider being proportionately greater, the valves necessarily quickly assume their original adjustment.



NEW ADJUSTABLE PISTON VALVE.—INVENTED BY M. E. H RSHEY.

It is the employment of the metals of varying expansibility that makes the positive valve adjustment practicable. The brass spider, having the greater range of expansion, is so constructed as to be most susceptible to the change of temperature. The general construction is shown in the cut; it will be observed that the peripheral adjustment to compensate for wear does not affect any other adjustments for steam distribution.

THE MILLING-MACHINE IN PLACE OF THE PLANER.*

By W. S. Rogers.

IN the present day, when old machinery has served its allotted time of usefulness in the shop and must be replaced by tools replete with modern ideas, it is a matter of no small amount to every practical, progressive shop-director having the responsibility of the semi-annual dividends thrust upon his shoulders, to determine just what type of machines to select which will be best adapted to his special line of work.

For example, if the work has always been done on planers, and they are peculiarly adapted to it, would it be advisable to replace the old ones with new ones with latest improvements and added strength? If so, what will be the percentage of gain in time over those now in use? Or shall a milling-machine be the tool to be placed on trial to shorten the present hours of work performance? And also, what type?—not whose make. In all the written data relating to milling-machines and their many good qualities, the writer has been unable to discover anything which would enlighten him in such manner that he could know intelligently and to a certainty which type of machine would be the most desirable for the class of work to be operated upon. It has been found during investigation preparatory to purchase, in answer to the all-important question, How much work will the milling-machine perform in a given length of time, and how will that amount compare with the work produced from the planer in the same time? that the builders of machine tools give nothing definite whereby we can base our calculations. They confine themselves generally to the superiority of their manufacture over competitors, which we always concede.

* Paper read before the American Society of Mechanical Engineers.

In the example which I shall quote, one manufacturer of both planers and milling-machines, who knew from personal observation just what the class of work was, expressed himself favorable to the planer as being the machine best adapted for it. But a decision being made in favor of the milling-machine, and the type known as a "slabber" being chosen, it was bought and placed in position in the works, especial attention being given to its foundation, and warning being given to its maker that it would be subjected to the severest duties in its battle for supremacy over its rival, the planer, and the true merits of the milling-machine demonstrated in comparison, if possible. I would like to add in parentheses, I have always thought the builders of this especial machine were a little bit more slack about it than they would have been if they had not received our "warnings."

The planer used in this test is of modern build (being about three years old), carries two heads, and is 30 x 30 inches x 8 feet, having a table travel of 27 feet per minute. The tools used are Mushet's steel, one and one-half inches square. Both machines are fully equipped with chucks and clamping devices for suitably holding the work, and in charge of first-class mechanics of long experience, and between whom considerable rivalry existed. The favorable results from the milling-machine in comparison to the planer are somewhat surprising, even to those who know it best.

Eight pieces of cast-iron, 17 inches long, having a surface 8 inches wide and 1¼ inches down each side, to be rough finished, are done on the planer in 4½ hours, the pieces being placed on the platen in two rows, and both heads being used simultaneously. The time

required by the milling-machine was just 41 minutes, strandle-mill cutters being used and one casting being operated upon at a time, the amount of metal removed being about one-sixteenth of an inch in both cases.

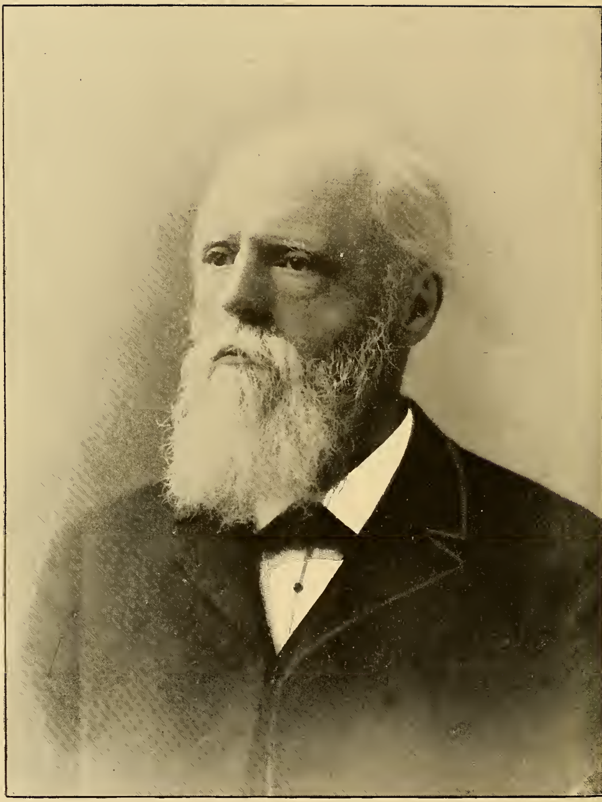
Another class of work was cast-iron strips 16 inches long, ½ inch thick, and 1½ inches wide, to be rough finished all over. The best time made on the planers was found to be at the rate of 4 every 36 minutes, while the milling-machine turned off 6 every 6 minutes. The planers in this case were small modern machines, carrying single heads and having a cutting speed of 22 feet per minute. The spindle of the milling-machine makes 34 revolutions per minute, while the platen travels 13 inches in the same interval. The platen travel per minute has been doubled after coming to the works without affecting the cutter rotation. Another item of importance brought out was the fact that the cutters were colder and held their cutting qualities longer when the speed of the platen was increased and the work forced harder against them, thus conclusively demonstrating, to the writer, at least, that it is frictional contact which tends to dull the cutters and wear them away by grinding, and not the actual work performed. Memoranda kept during the past year also indicate the cost for renewals for cutters and grinding to be about 25 per cent. less than the running expenses for planer tools.

Another important practical result brought about by the milling-machine after it was in full service was the total abandonment of three planers and one shaper, previously used on this work, all of which now goes to the miller, and an increase in the capacity of production of over 25 per cent.; thus at the same time bringing about a greater uniformity of work than could possibly have existed under other conditions, and, lastly, causing a reduction in the pay-roll, not from a reduction of wages but because fewer men were required.

To the writer, these figures from the milling-machine are not conclusive nor satisfactory. I think the platen travel of this type of machine can be increased to 20 inches per minute under the same conditions for "roughing off" work and leaving enough for finishing. I speak now only of cast-iron; steel and other metals would be slower in proportion. There are to-day a thousand-and-one varieties of heavy work being done slowly on planers which should be done rapidly on milling-machines, but the milling-machine must be designed and patterned closely upon the lines of the modern planer, and must universally reach over and around the work on the platen, and be as easy to handle and operate as the present planer is to-day.

Another thought brought out from close association with a miller is the inconvenience at present existing for clamping and chucking the work. If it requires 20 minutes to clamp a piece on the planer and 1 hour to plane it, and only requires 20 minutes milling, but 1 hour is used up in clamping it securely on the miller, the latter becomes an expensive tool and all the argument is in favor of the planer.

I have said nothing about the overhung-arm type of milling-machine in this paper, as it covers a field of its own in competition with small planers, shapers, and slotters, doing nice work and reasonably rapid, but as yet not up to what its possibilities are, the reasons being chiefly that it is lacking in rigidity and strength in its component parts.



Chas. T. Porter.

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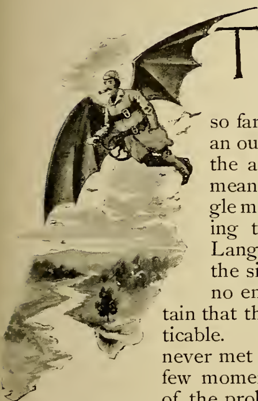
MECHANICAL FLIGHT.

By John P. Holland.



THE ingenuity of man, assisted by all the resources of science, has so far failed to support an ounce weight free in the air, by mechanical means, for even a single minute. In asserting this Professor Langley stated only the simple truth. Yet no engineer will maintain that that feat is impracticable. The writer has never met one who, after a few moments consideration of the problem, apart from any particular plan, was not ready to express his confidence that some one will soon succeed in navigating the air, possibly much sooner than those who believe it practicable expect, and to admit that the means of succeeding are now available and the difficulties already mainly overcome, those that remain being chiefly imaginary or due to imperfect knowledge of the conditions to be fulfilled.

The day of success is delayed because the men who possess the education and experience requisite to qualify them for the work are, with a few honorable exceptions, too busy with other matters, or else they lack courage. No one is willing to invest money in a project that appears new and uncertain, because he can see that it is carefully avoided by most engineers, even though it be indorsed by those he consults. Fear of ridicule, and not fear of failure, prevents experiments and free discussion of the subject, and yet those who are chiefly responsible for its neglect are the persons most directly interested and on whom its future development must entirely depend.

The following pages are submitted as a study, in the hope that those possessing fuller or more exact information on the matters considered may correct what may be wrong, add the weight of their authority to what is right, or contribute independent information that will be of real value to experimenters.

Much has already been accomplished in this direction by Mr. Octave Chanute, Professors Langley, Thurston, Zahm, and others in this country, and by many foreign investigators; but still more remains to be done before it will be regarded as being fairly within the domain of serious engineering.

It may assist in our study to consider what conditions are required in an aerial machine, in order that it may be safe for the experimenter, and capable of traveling a considerable distance under perfect control, and at good speed, and then to find whether we have the requisite means available.

1. It must be strong enough to endure all the strains to which it may be subjected, and have a considerable margin of safety or strength remaining.

If we employ steel for every part sub-

ject to tensile strains, hard seasoned ash for those enduring compression, and silk for covering the aeroplanes, screws or wings, and body of our machine, there will be no occasion for employing any expensive or untried material in our experiments. This shall be shown later when we come to examine the functions of the parts that may be required in a practicable flying machine.

2. The aeronaut must be able to alight without shock or injury to himself or his machine ; because, until this is assured, no one will be willing to risk getting a broken neck in the interest of aeronautics.

This is a simple matter in a machine that employs a pair of propeller screws on concentric or parallel axes capable of inclination between the horizontal and vertical positions, in connection with aeroplane surface of ample area. As a machine of this kind should be able to rise from a level surface, in still air, the power that lifts it, when rising, can be reduced so as to regulate its speed of descent and cause it to rest on the ground without injury.

If the power employed be not sufficient to lift the total weight directly, although it be enough to support it with the assistance of aeroplanes when moving horizontally, the rise and descent must be made against a strong wind, or the machine must be launched from an elevated position when starting and rise from a low to a higher level, and rest on some elevated place when the energy due to its speed is absorbed. Observers of nature notice that birds of all sizes face the wind, when it is considerable, both in rising and descending. The larger birds select elevated points, such as rocks or tree branches, on which to rest, so as to be able to launch themselves and attain full speed of flight with the least delay and exertion. It has also been observed that they reach those resting places neither by descending nor by horizontal movement, but by

FIG. I.—FLYING MACHINE RISING OR DESCENDING.

rising from a lower level and alighting after a few vigorous wing strokes against the direction of motion.

3. The machine must be able to travel at good speed, say thirty miles per hour, at least, and steadily; that is, without any tendency to plunging or diving like an unbalanced kite.

The speed depends on the amount of power available, and on the smallness of the surface and bulk relatively to the weight. For example, a vulture can travel six times faster than a crow, but it has only one-third as much wing surface in proportion to its weight. One horse-power, equal to 550 foot pounds per second, applied to towing a flat aeroplane, 184 square feet in area, weighing 118 pounds, and set at an angle of six degrees, at a speed of twenty-five miles per hour, equal to 36.66 feet per second, will overcome a six times the space in the same time, the work performed remains the same, —$2.5 \times 36\frac{2}{3} \times 6 = 550$ foot pounds = 1 horse power. Before the angle was reduced and the speed increased, the proportion stood 1.56 square feet per pound weight. After the change was made the proportion became .166 square feet per pound weight.

If our machine have the speed, surface, and inclination of aeroplanes necessary to support its weight it will fly just as steadily as a properly balanced kite, if corresponding conditions are observed; that is, if the centre of gravity is at a proper distance vertically under the centre of pressure or support, and if the point at which towing power, or thrust, is applied is on the intersection of the horizontal and vertical planes passing through the centre of pressure or resistance.

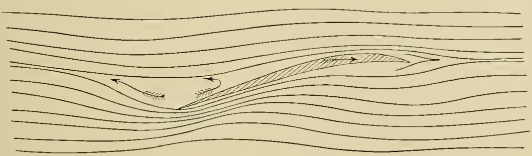


FIG. 2.—PROBABLE ARRANGEMENT OF STREAM LINES DURING MOVEMENT OF CONVEXED AND CONCAVED PLANE.

resistance of $550 \div 36.66 = 15$ pounds while doing that work.

If the inclination of the plane be reduced to one degree, and the speed made six times greater, the reduction of the angle reduces the lifting power to one-sixth, but the increased speed raises it again as the square, or 36 times—$36 \times \frac{1}{6} = 6$. Therefore the same plane lifts six times as much with the new inclination and speed; and the original weight will be supported at the new speed with one-sixth of the plane area.

The reduction of angle reduces the drift to one-thirty-sixth, and the increase of speed raises it again thirty-six times, restoring the original resistance, fifteen pounds. When we reduce the plane area to one-sixth, equal to 30.66 square feet, we reduce the drift to 2.5 pounds; but as it is exerted through

The chief problem awaiting solution, in the opinion of some investigators, is to find a reliable method of controlling its motions in the air, the power question having been disposed of long ago by the construction of torpedo-boat motors weighing sixty pounds per horse-power, the Norwood's, nineteen pounds per horse-power, Mr. Stringfellow's steam motor weighing thirteen pounds per horse-power, and Mr. Maxim's, weighing nine pounds per horse-power. The impracticability of holding a thin, weak plane to its work, when the speed is high and the inclination under two degrees to the horizontal, is the basis of this difficulty. Under these conditions the plane is liable to vibrate and to lie sometimes parallel with its direction of motion, or to dip its leading edge or one of its sides, thus sustaining

pressure on its upper surface on the part depressed, and causing the machine it supports to tip sidewise or plunge downward ahead. With these difficulties to encounter, steady horizontal motion and steering would be puzzling problems. However we can avoid instead of meeting them by forming our aeroplanes in narrow superposed sections, placed far enough apart to prevent interference with each other, and by making the upper surface convex, with the greatest rise near the leading edge, and the under, or pressure side, slightly concave. Mr. Horatio Phillips has proved that this change increases the efficiency in lifting 2.74 times without increasing the towing or drift force, and that a plane of this section left free to set its own inclination being held near the leading edge—would lie with its posterior or trailing edge at a higher level than its anterior or leading edge. As the curved shape of the upper and under surfaces, and the thick space between them, afford facilities for stiffening the planes, neither weakness nor vibration may be expected; and there remains only the question of steering a body immersed in a fluid, as a submarine boat or automobile torpedo when running submerged. It is clear that these cases are analogous and that the aerial machine, when properly designed and constructed, can be as easily steered in every direction as the submarine boat, and by similar manual or automatic devices.

If we take some bird for the model of our machine and adopt its method of rising, progressing, and descending, the surface, weight, power, and speed, will bear a certain proportion to each of these particulars in the bird, provided the mechanical efficiency in each case is equal. But as this is unattainable, greater proportionate power must be provided. Some modification of other particulars must also be made to fit it for being controlled by a more inexperienced operator.

The rules relating to the ratios between models and the things they represent may be quoted as follows:

Proportionate power is as the cube of the ratio of some similar linear dimensions.

Proportionate weight is in the same ratio.

Proportionate surface is as the square of the ratio of similar linear dimensions.

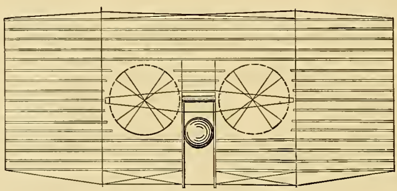


FIG. 3.—APPEARANCE OF FLYING MACHINE FROM IN FRONT.

Proportionate speed is as the square root of the ratio of similar linear dimensions.

In the case of a machine to be operated by a man's muscular power, the spread of wings—copying the albatross of eighteen pounds weight, twelve feet spread of wings, twelve square feet surface, and thirty-five miles mean speed—will be as follows: supposing the man to weigh 150 pounds, and his machine thirty pounds, total, 180 pounds,

$\sqrt[3]{18} : \sqrt[3]{180} ::$ 12 feet : 25 feet 10 inches.

The wing surface will be 55.676 square feet, and the mean width, 2 feet 1.8 inches.

If his machine be as efficient as the mechanism of the albatross he need exert only ten times as much power,

and his speed through the air with a machine of the dimensions determined will be $\sqrt{2.15441.}=46$ times greater.

There are reasons for believing that the power expended by the albatross while soaring must be very small, and that the same kind of flight may be attained by a man in a suitable machine; but it is probable that the gain in speed must be sacrificed on account of imperfect efficiency.

Even at the risk of being thought visionaries, we may venture to consider for a few moments what grounds we have for thinking that a man may be able to fly with wings like a bird. Dr. Freninges, of Copenhagen, lifted a weight of six pounds with a propeller-wheel 1 foot in diameter, 1 foot pitch, 1-7 square foot area of blades, .35 pound weight, and a speed of 52 revolutions per second. This speed was equal to 89.29 miles per hour at the centres of effort of the blades. The pressure per square foot on a surface exposed at right angles to wind at this speed would be only 39.86 pounds. But the lifting pressure on Dr. Freninges' screw blades was at the rate of 42 pounds per square foot, even though they were set, at the centre of effort, at an angle of 21 degrees 42 minutes to the plane transverse to the axis.

An English investigator found that a model section of an albatross's wing, having its lower surface nearly horizontal, with scarcely a perceptible rise at its anterior edge, lifted 40 pounds per square foot when its horizontal speed was 40 miles per hour. The wind pressure due to this speed is 8 pounds per square foot. These things are paradoxical, but Professor Langley's assertion that the power to tow a loaded aeroplane through the air grew less with increasing speed, instead of increasing as its square, was even more paradoxical; yet he has proved it to be a fact.

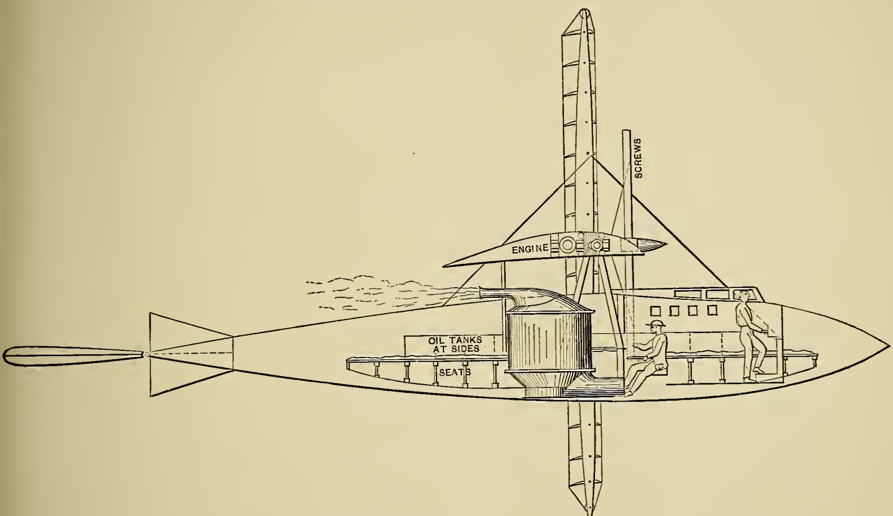


FIG. 4.—SIDE ELEVATION SECTION, SHOWING MOTOR.

In view of these facts we may study whether we can imitate the soaring flight of the albatross.

A bird such as the albatross moves in sideward curves, rising and falling as it progresses. The wings are held extended rigidly, the one that points

toward the centre of the curve it sweeps around is descending, while the outer wing is rising, both lying horizontal when the greatest elevation is attained. At this point the speed is least. When near the surface of the water the speed is greatest. Both wings now act as aeroplanes, but they utilize in lifting force only a part of the energy due to the speed, thus reducing it. When the highest point is reached the outer wing acts as an aeroplane, the bird at the same time turning its head and tail toward the centre of the curve to be next swept through, thus throwing the centre of gravity toward the inner wing and reversing the curve of direction of motion. The outer wing, as an aeroplane, supports part of the weight; the remainder of its lifting force causing a revolving motion around a longitudinal axis because both wings are held extended rigidly; but the total lifting force exerted is now less than the weight, therefore the bird descends. Both wings revolve during the descent through about 90 degrees around the centre of gravity which lies toward the inner wing, the outer one rising and acting as an aeroplane, its anterior edge being elevated, the inner wing descending with its anterior edge depressed, thus acting as a screw and producing propulsive or drift force. The fulcrum for this action is the inertia of the falling weight during the descent, the upward pressure under the rising wing, and the energy of motion developed by the change of the position of the centre of gravity.

The energy that produces these motions is exerted in changing and maintaining the inclination of the wings against pressure, and it is expended chiefly in twisting or revolving the descending wing not around a line joining the centres of pressure, but around a transverse axis with which the leading edge of the inner half of each wing nearly coincides. The outer halves incline slightly backward, and therefore absorb considerable force while revolving against the increasing pressure due to the accelerating speed of descent. The inner or descending wing thus acts as a screw, developing propulsive force.

That the drift force developed by one wing, although very small, is yet quite sufficient, will appear from the following:—The total propulsive force required is equal to the drift force that would tow the bird's weight at a mean speed of 35 miles per hour, employing an aeroplane of 12 square feet area, plus power spent on friction of the mechanism and friction of the air. There is good authority for saying that these two losses may be neglected in the case of the bird, although the friction of the mechanism of a similar machine would be considerable.

We have seen that one square foot of aeroplane with "barely perceptible inclination" supports 4 pounds at 40 miles speed. Twelve square feet would support 48 pounds under the same conditions. As we want to support only 18 pounds the drift force will be reduced in proportion. M. Chanute's table of pressure on inclined planes shows that at one degree of elevation the lift force is 57.28 times the drift. Correcting this figure for the improvement due to convexed upper surface, the lift will be at least 157 times the drift. The weight to be supported, eighteen pounds, divided by 157 gives the total drift force, .1146 pounds. This drift, multiplied by the speed, gives the total power exerted by the albatross when moving 35 miles per hour, $.1146 \times 51.33$ feet per second $= 5.88$ foot-pounds per second.

It has been shown above that the work required of a man to accomplish the same speed in a similar machine will be only ten times greater.

$5.88 \times 10 = 58.8$ foot-pounds per second.

That this work is not difficult will be evident when we remember that a man at ordinary labor does the equivalent of lifting 70 to 80 pounds one foot high per second for ten hours per day.

If the work of the albatross be calculated from Mr. Chanute's table—inclination $1\frac{3}{4}$ degrees—other conditions being the same, and the correction made for convex back, it will be found to be 8.78 foot-pounds per second.

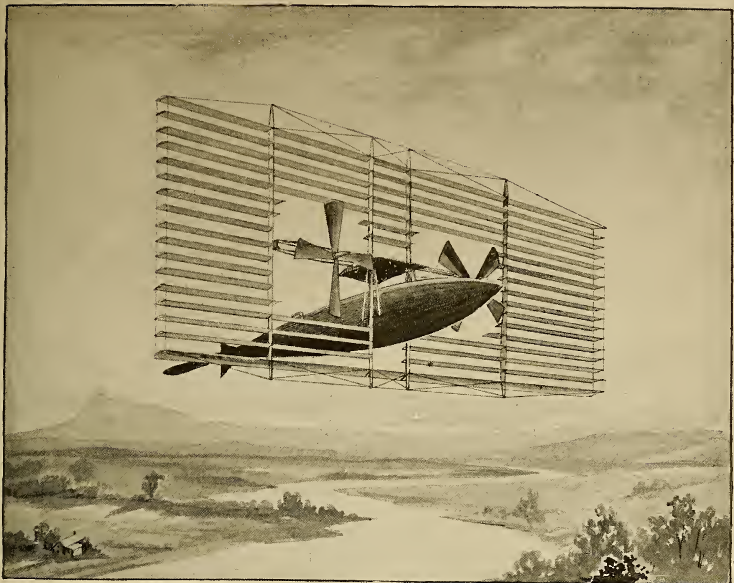


FIG. 5.—MACHINE IN FULL HORIZONTAL FLIGHT, SEEN FROM THE RIGHT AND UNDER.

Having advanced reasons for believing that a man can fly with wings, our next step will be to find whether a practicable solution of the problem of air navigation is attainable with a machine of simple design and of less exact construction than is required in one modeled on a bird.

The question stands thus: Can we build a kite, or its equivalent, large and strong enough, and push or tow it fast enough through the air to support itself, its motor and accessories, and some weight besides its operators? Can we cause it to rise from a level and descend without accident, and travel steadily in any desired direction?

A study of the things available and what we require of them will assist us to estimate our chances of success.

The size and capacity of our machine and its accessories will be determined by the power of the motor employed, and this must be large because a small one will not do as much work in proportion to its weight and consumption of fuel, that is, it cannot be so economical.

Suppose we employ steam engines and a boiler capable of indicating 400 horse-power, and a pair of air propeller wheels revolving in opposite directions.

We will deduct ten per cent. for friction in the machinery, and if our air propellers prove to be as effective as some that have been tested they will give an efficiency of over eighty per cent., thus rendering effective seventy-two per cent., or 288 of the 400 indicated horse-power.

The propeller wheels are placed on parallel or concentric axes capable of inclining from the vertical to the horizontal position and *vice versa.* Their power is first applied to lifting the machine vertically. When all elevated objects are cleared, the screw shafts are gradually inclined from the vertical,

thus bringing a horizontal force, proportional to the size of the angle of inclination to the vertical into action at the expense of the elevating force. The latter can afford to suffer a considerable diminution before being reduced to a point at which it could no longer support the weight of the machine, because the weight to be lifted must be so proportioned that the power can not only lift it at the start, but also give it a considerable upward velocity, say three feet per second. The weight multiplied by this speed is equal to the power spent in imparting upward velocity while ascending, and also what is available for beginning horizontal motion, and calling the aeroplanes into action. Every succeeding degree added to the inclination reduces the direct lift ; but as there is a corresponding supporting power developed by the aeroplanes, the machine will lose nothing in elevation. This process continues until all the power is applied directly to propulsion or drift, the weight of the machine being supported by the corresponding lifting power developed by the aeroplanes.

In order to descend the method of managing the ascent must be reversed, but the operation may be completed much more rapidly. In both cases the speed of the wind must be taken account of by facing the wind and by beginning the ascent and finishing the descent with an inclination of the screw shafts, capable of imparting a horizontal velocity that compensates for the wind's speed in the opposite direction. The path, both in ascent and descent, will be represented by a vertical and a horizontal line connected by a curve to which each will be tangent.

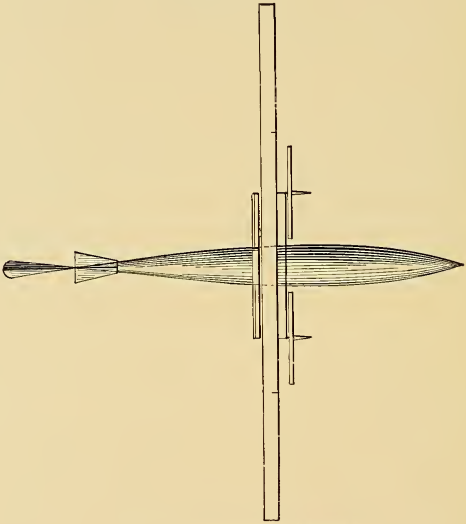


FIG. 6.—PLAN VIEW OF MACHINE.

The lifting power of screws next claims consideration ; and it may be said that the experiments made with this object in view, the particulars of which have been published, have been indecisive and unsatisfactory, owing chiefly to the unsuitable proportions of the screws employed. Other defects have interfered with efficiency in some cases, but this one was found present invariably.

Mr. H. S. Maxim obtained an efficiency of 66 per cent. with a screw 17.5 inches in diameter, 24 inches pitch, making 2800 revolutions per minute, and traveling at a speed of 3700 feet per minute, the thrust being five pounds ; but the same screw, at the same speed of revolution, when prevented from moving forward, developed a thrust of only eight pounds. Another screw developed the high efficiency of 81.45 per cent. with a thrust of eleven pounds, while moving at a speed of 5700 feet, with 2333 revolutions per minute. The diameter was 25.4 inches, and pitch 36 inches.

These cases cannot be properly analyzed because some essential particulars are wanting. The power applied to the first was 28,000 foot-pounds, and the work exhibited was 18,500 foot-pounds. But when the screw was prevented from moving forward it required 44,800 foot-pounds to produce a thrust of eight pounds. When the resistance to thrust was reduced to five pounds, a speed of 3700 feet per minute was obtained ; the work spent in revolving the screw fell, at the same time, from 44,800 to 28,000 foot-pounds. The additional three pounds resistance caused all the power to be expended on slip. Supposing the centre of effort to have been at .7 of the radius, and that the inclination at that point was about 16 degrees, there must have been a revolving power of about five pounds applied there.

An inclined plane possessing similar surface, speed, inclination, and drift force, calculated from Mr. Chanute's table, would give a steady lift of 11.74 pounds with the same efficiency. If the plane be concaved on its face and made two or three times more convex on its back the lift will be increased to 32 pounds. If the inclination be now reduced to four degrees, and the speed doubled, the lift will remain the same, but the drift, that is, the power expended, will be reduced to one-fourth. If we do not reduce the power we can therefore lift four times as much, $32\times4=128$ pounds, but the surface must be made larger. These changes in the inclined plane are equivalent to doubling the diameter of the screw, maintaining the same proportion of surface, and number of revolutions, but reducing the inclination of the blades at the centres of effort from 16 to 4 degrees.

Mr. Maxim did not construct his screws for lifting, but to be effective when moving horizontally, and for that purpose they appear to be unexcelled. A combination of the two qualities—great lifting power and efficiency when moving rapidly—is what we require, and it is evident that we shall have it if we can construct a screw having a very short pitch, or small inclination relatively to its transverse axis, while it is employed in lifting, and that can automatically alter its pitch as the thrust or lifting power is reduced. There are many devices in existence for so changing the pitch and almost any of them will answer our purpose. The efficiency in pushing was, with one of Mr. Maxim's screws, 81.45 per cent. One horse-power per second is 550 pounds lifted one foot. The same percentage

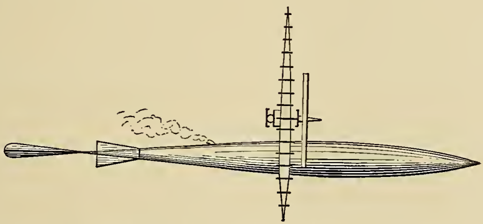


FIG. 7.—SIDE VIEW OF MACHINE IN FULL FLIGHT.

of this will be $550 \times 81.45 = 447.97$ foot-pounds. That is, one horse-power can lift 447 pounds one foot high per second with either screw or aeroplane when properly designed. We want to lift our machine three feet high per second, therefore it may have a weight of $447 \div 3 = 149$ pounds per effective horse-power provided. This degree of efficiency would be quite unattainable with flat surfaces in screws and aeroplanes, and even if it were approached it could not be maintained with the materials suitable for a flying machine on account of their want of rigidity and stability when set at small angles.

The accompanying diagram (see Fig. 2) may suggest an explanation of the great efficiency of the convexed and concaved planes. The direction of motion of plane is indicated by the arrow on its section. The air stream lines begin to be formed in advance of the plane, acting as if they felt its approach, and dividing at a slightly higher level than its leading edge. Those that pass below are bent downwards, but recurve quickly, owing to the fluid pressure and the elasticity of the air, and they strike the under side of the blade in a direction approaching the normal on account of the recurving and the concaving of the surface. The part that recurves has its effectiveness increased as the square of the velocity due to elasticity, and this is in addition to the pressure due to the speed of passage and inclination of the blade.

The stream lines passing over the blade are bent upward and left behind by the rapidly advancing plane. The elasticity and pressure of the air causes them to recurve downwards, but not fast enough to lie against the back of the plane where, in consequence, defective pressure must exist. This defective pressure or partial vacuum is made more intense by the rubbing of the streams against what air may follow the blade, thus drawing it away by friction or suction, and its intensity is increased probably as the square of the speed up to perfect vacuum. As the partial vacuum on the back is exerted in a direction opposite to the line of progress of the plane, it is just as effective as an equivalent positive pressure against the under side of the plane.

An air screw with a flat under surface and convexed back will operate efficiently when both the leading and trailing edges are on the plane of the direction of motion of the blades; that is, when the apparent angle of incidence of the air on the under surface is nothing. This condition of negative slip in marine screws is wasteful of power on account of the great increase of friction, but it is well known that when all longitudinal sections are ship-shaped, the question of air friction may be neglected with aerial machines.

We have available 288 effective horse-power; and it has been shown that we can lift 149 pounds per horse-power and elevate it at a speed of three feet per second. If the speed of rising be reduced, the weight may be increased correspondingly.

$149 \times 288 = 42,912$ pounds.

With a lifting force of 149 pounds per horse-power at our disposal, there is scarcely any necessity for expending much ingenuity in the construction of very light engines, especially if they prove to be very costly. Motors similar to those employed on some launches, but modified to suit the circumstances, would serve our purpose quite well enough. We shall find, however, that a motor of great strength and lightness can be built for very little more money than should be paid for first-class launch engines, specially built. Professor Albert F. Zahm has shown us how a very light boiler may be built. "A boiler, for example, of quarter-inch tubes possesses sixteen times as much heating surface and, consequently, sixteen times as much evaporative power as a boiler of equal weight of four inch tubes." For the same power the weight would then be only one-sixteenth. We can build a very light boiler of one and one-quarter inch and five-eighth inch straight tubes, twenty-six diameters long, and by employing electric welding instead of screwed or expanded joints it will be practically all in one piece. Our engines may be quadruple expansion,

having two cylinders connected to each screw. Instead of employing heavy castings for the cylinders they may be built of thin flanged steel tubes properly braced. The cylinder and piston heads can be formed of dished steel discs with re-enforced flanges. There will be little difficulty in building engines, boilers, and their accessories in this style that shall weigh, when complete, with a charge of water, and ready for action, not over thirteen pounds per horse-power.

$400 \times 13 = 5200$ pounds for the motor.

The action of the motor may be made perfectly automatic, as the fuel burned will be petroleum. It will require no extra care in handling, as there will be no variation of the power from the start until it is reduced when preparing to descend. The relative gain of power due to reduction of weight by fuel consumption will be spent on increasing the speed.

In order that our machine may be compact, yet speedy and manageable, we must have as little aeroplane surface, and of as little spread, as possible. To determine its area we must find what speed can be made.

Two hundred and eighty-eight horse-power is equal to 158,400 foot-pounds per second.

Ninety miles speed per hour is equal to 132 feet per second; 158,400 foot-pounds $\div$ 132 feet per second is equal to 1200 pounds drift force.

$$\frac{\text{Total lifting power, } 42{,}912}{\text{Total drift power, } 1{,}200} =$$

35.67 = ratio of lift to drift force.

$$\frac{\text{Ratio of lift to drift, } 35.67}{\text{Co-eff. for convexed planes, } 2.74} = 13 =$$

ratio of lift to drift for flat plane with square edges. By consulting Mr. Chanute's table we shall find that this corresponds with an inclination of about 4.5 degrees. The wind pressure due to ninety miles speed, 40.5 pounds, multiplied by the drift co-efficient for 4.5 degrees, gives the drift pressure per square foot of aeroplane :

$40.5 \times .01245 = .5042$ pounds drift per square foot.

Total drift force, 1200 pounds, divided by drift per square foot.

.01245, gives the extent of aeroplane surface required.

$$\frac{1200}{.01245} = 2{,}379 \text{ square feet surface.}$$

This surface may be most conveniently disposed by arranging it in fifteen superposed planes, each eighty feet long, two feet wide, and spaced two feet apart.

The spindle shaped body of the machine that carries the machinery and operators will be placed under the centre of the set of planes, with the axes of the screws slightly under the centre of pressure when moving horizontally. The centre of gravity may be four to six feet under the centres of pressure and support by this arrangement. (See Figs. 3, 5 and 7.)

The trussed frame carrying the engines and screws will be solidly connected to the frame carrying the aeroplanes, the screw shafts being placed at right angles with the plane of their trunnioned ends. The aeroplanes, engines, and screws revolve together through ninety degrees during the change from vertical to horizontal motion during the ascent, and return during the descent.

In order to make room for the body and screws, an open space must be provided in the set of aeroplanes, and compensation for the corresponding loss of surface must be made by adding a sixteenth plane.

When the machine lies on the ground the aeroplane frame will be nearly horizontal, and it will stand nearly at right angles to the axis of the body when moving horizontally (see Figs. 1 and 5).

As we have so large a margin of carrying power, there is no necessity for going closely into an estimate of the weight. Each aeroplane will require the equivalent of an ash pole eighty feet long, and about two and one-half inches in diameter. The frame carrying it will require two thirty foot pieces about one inch thick, and six inches wide at the centre. The body will require the equivalent of four sixty foot pieces

about three inches in diameter, with a small floor and hoops.

The wood required for the whole structure may be roughly estimated as equal to twenty-four 80-foot poles, two and one-half inches in diameter, and tapering to the ends. Their weight will be

$24 \times 80 \times .034$ square feet $\times .6$ for taper $\times$ 50 pounds $= 1958$ pounds.

Allow one-half as much for ribbon stays of steel, and ash struts, say 1000 pounds; total, 3000 pounds.

The machine weighs 3000 pounds.

The motor complete and water, 5200 pounds.

Total weight of machine and motor, 8200 pounds.

$$\frac{\text{Total weight, } 8{,}200}{\text{Effective power, } 288} = 28.4 \text{ pounds}$$

per effective horse-power.

It is clear that everything may be four times heavier and yet be within practicable limits.

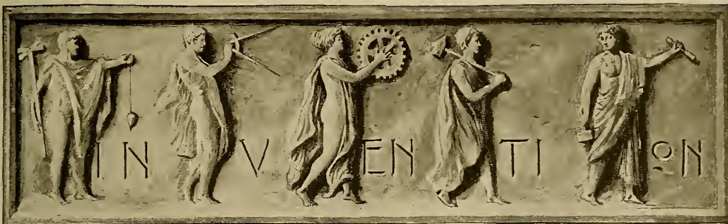
The consumption of petroleum will be about one pound per horse-power per hour. The mean weight, if only oil for fuel be carried, is equal to one-half the sum of the total lifting power, and the weight of the complete machine, without fuel:

$\frac{42{,}912+8{,}200}{2} = 25{,}556$. This divided by the lifting power of one horse-power gives the mean power required.

$25{,}556 \div 149 = 175$ horse-power. As each horse-power requires one pound of oil there will be a mean consumption of 175 pounds per hour. Carrying power, $42{,}912 - 8200 = 34{,}712$ pounds of oil; say 34,000 pounds, to allow for crew and supplies.

$34{,}000 \div 174 = 194$ hours' flight, and supposing the mean speed to be no higher than ninety miles per hour, the distance covered will be $194 \times 90 = 17{,}460$ miles, or about one-half that distance with one-half of the carrying capacity devoted to fuel and the remainder to cargo.

Now, where are the serious omissions or oversights which, in the estimation of so many learned critics, render this project unworthy of consideration?



NOTES ON NEW AND PATENTED INVENTIONS.—V.

By John Richards, Editor of "Industry."

THE flexible title adopted for these articles permits the notice of patents of any date. The intention is to confine the subject mainly to new inventions, but for a divergence, and as a matter of some interest, no doubt, the patent granted June 24, 1642, by the British Patent Office, and numbered 127, now two hundred and fifty years old, has been selected for notice. It was granted 150 years before the United States Patent Bureau was established, and is one of those quaint old productions containing essays, propositions, theorems, and arguments, also replies to specific objections, a Dutch patent communicated from the Netherlands soon after the Monopoly Act was abrogated in England.

It is a water-raising wheel, entitled by the patent office "a water-scoop wheel," and the patent was issued to William Wheeler. It was an improvement on the common water raising wheels, such as are yet extensively employed in Holland, the low counties in England, and also at New Orleans in this country, where there are several now in use to raise the city drainage so it will flow back to Lake Ponchartrain.

The inventor, like some at our day, did not lack either the confidence or courage to set forth his improvements. The water follows up the spiral compartments as the wheel revolves and runs out at the centre. The inventor says the power required is as the distance of the water from the axis, and that:

"A water-scoop wheel in a water mill will raise water from 11 to 12 feet high with the same speed and working power, and with greater ease and in greater quantities, than three mills with the common water-raising wheels."

He winds up fourteen pages of description matter and argument with the following for the doubting:

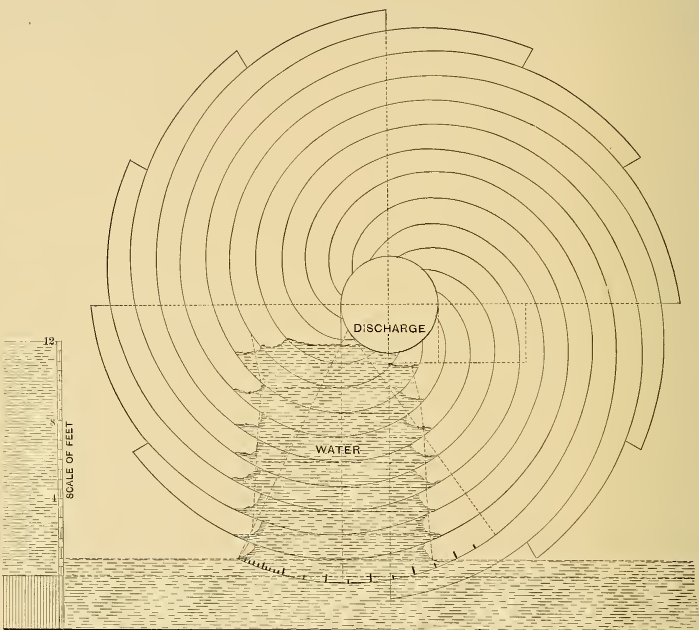
"As for those who judge by slow understanding or careless reading, nothing can assist them. I did therefore care but little, or not at all, for the approval of such persons, merely endeavoring to demonstrate my proposition for intelligent readers, so as to deduct therefrom all circumstances relating thereto, allowing the working of the wheels (which in proper time shall give better proofs of themselves than I can) to instruct those who cannot be convinced by arguments."

We cannot refrain from printing the original Dutch patent on this wheel, dated June 18, 1639, two hundred and fifty-three years ago.

"The States General of the United Netherlands, to all whom it may concern, greeting.

Be it known that we have granted,

and by these presents grant, to William Wheler, English gentleman, for the next twelve years, the exclusive privilege of making, practicing, and working, and of allowing to be made, practiced, and worked, in these United Provinces and towns, several of his original inventions that are worked: viz., of raising water in great quantities to a moderate height of from three to six, twelve feet and more. Also for raising mean quantities of water to great height; great quantities being raised by hand, horse-power, or wind; smaller quantities by hand, horse-power, wind, water, or weights. We expressly forbid all inhabitants of this country, within the prescribed term of the next twelve years, to make, or cause the said inventions to be made entirely or partly, on a large or small scale, directly or indirectly, or to import counterfeits into the United Netherlands, for the purpose of selling or using them without the consent of the said William Wheler, under the penalty of forfeiting all counterfeits, and of a fine of five hundred Carolus gulden, to be disposed of as follows:—One-third for the benefit of the officer who effects the seizure, one-third for the poor, and the remaining third part for the benefit of the said William Wheler. Provided that it be a new invention, not made and worked by anyone else in this country, and provided also that he brings the same into full practice within one year from the present date, under the penalty of forfeiting the present Octroy, and without prejudice to all preceding general and particular grants. We, therefore, order and command all justices, officers, magistrates, and inhabitants of the said United Netherlands, and all those whom



WATER-SCOOP WHEEL.

it may concern, to let the said William Wheler enjoy and use our present Grant and Octroy to its full extent and without hindrance.

Given at the assembly of the high States General, at the Hague, on the 18th June, 1639."

(Signed) S. V. HAERSOLTE.
CORNELIS MUSCH.

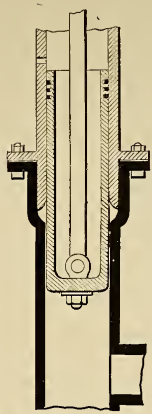
The British patent contains five double sheets of well executed drawings, only one diagram of which is reproduced here to show the nature of "Wheeler's wheel." One may well smile at the sanguine hopes that impelled this inventor to write a treatise and secure the action of the ponderous States General, without the trouble of making a wheel and seeing how much "wind" it would take to drive it, but there are people at this day, perhaps a good many, who will conclude that this scoop-wheel will somehow "coax" the water up without much power, as Mr. Wheeler did.

British Patent No. 5228, 1891.

E. STANSFIELD—PUMPS.

The device shown in the diagram is one that has obvious merit. It consists in providing a pump with a close-fitting sleeve around the ram instead of the usual gland, the sleeve being made of non-corrosive metal bolted down firmly to the pump barrel, and made long enough to cover the stroke. Packing rings are set in the ram to prevent leak past its sides, and as the liquid being pumped is not likely to find its way up around the plunger during a single stroke, it is very possible that with clean water a close joint can be maintained without the usual fibrous packing or cup-leather.

The long fit of the ram is a considerable agent in this matter. It prevents wear by reason of diagonal thrust, or other cause. These long fits around piston rods are doubtless a more practical expedient than is commonly supposed, especially for steam. Prof. Sweet's Straight Line Engine is an example of the kind. The piston rods have no fibrous packing, but pass through a long sleeve or gland that seems to perform well without the elastic element. The sleeves employed by Professor Sweet are of soft metal and compressible, but in so far as we know



E. STANSFIELD—PUMPS.

are never compressed, keeping on for years even, without leaking.

The progress toward metallic joints, for steam at least, has been regular and progressive. A long bearing and some intercepting grooves that fill with water are the main features, in this case carried out to an extreme.

U. S. Patent No. 478,088, July 5, 1892.

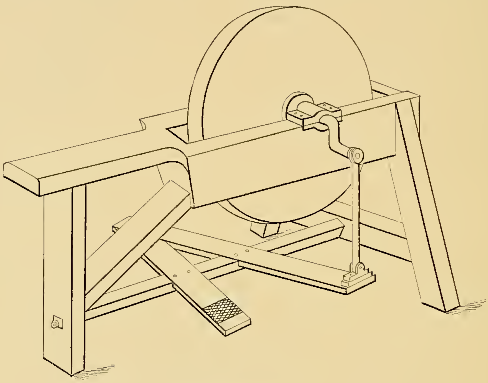
G. COCHINS—MECHANICAL MOTOR.

This patent is graphically illustrated by a man sitting astride a grindstone bench, operating a treadle extending across the frame with a pedal on each side, as shown in the drawing. The "operator" has been omitted in our diagram taken from the patent. The contrivance is simple and cheap in so far as mechanism, but the purpose of introducing the device here is to illustrate and assist in some remarks on treadle power generally.

One would suppose that anything so old as a treadle would long ago have been evolved into some common-sense form, but with the exception of sewing machines that are operated by the muscles of the foot and ankle, without

weight or without tramping, and the velocipede, which is a double treadle machine, we can refer to no example of treadle driving that is not bad.

The method employed for lathes, grindstones, and so on, is to stand on one foot and tramp with the other, which is awkward and objectionable. The supporting leg tires out directly, sooner even than the working one, and the operator's whole body, including arms and hands, is jerked about in a manner that prevents any accuracy or ease in what would be at an angle of twenty degrees or so from vertical, so the main forces, instead of being from the weight of the body, would be exerted by straightening the legs. This would call for a saddle, or some kind of back support, and would not only be easier, but permit the application of a force in emergencies exceeding what the weight of the operator affords, and would leave the upper portion of the body in a complete state of rest or steadiness. This may hardly seem an engineering subject, but it is certainly a mechanical one,



MECHANICAL MOTOR.

Sir Samuel Bentham calls "tool presentation." Anyone who for the first time attempts to use hand tools on a treadle lathe is defeated by this contortion of the body, and it is only experience and habit that a chisel or other tool can be held in proper shape. It is tiresome and unnatural.

Mr. Cochins has here introduced the true elements, namely, a treadle for both feet, and a rest for the body, and arms which are still, so as to permit free and exact use of the hands, but we think two separate treadles, "fore and aft," one at each side, would be better, also that in any operation requiring exactness of hand manipulation, "tramping" could be dispensed with. The treadle should be set forward and inclined, so the legs when straightened and relates to a class of contrivances that need reforming.

Shaft Couplings.

The patents on couplings are so numerous and so diversified that it is thought the subject will have more interest if treated generally, hence reference to particular inventions will not be given in this case.

MUFF COUPLING.

If one were to choose among the various mechanical devices in common use for one to illustrate the complexity and difficulty of perfecting even small details, no better subject could be chosen than couplings to connect together the ends of shafts.

Setting out originally, and proceeding by inference, the first thought would,

no doubt, be of a plain sleeve into which the ends of the two shafts should be fitted, and as first thoughts are apt to be correct ones there would be no great mistake in this case, because the plain collars or sleeves, commonly called muff couplings, shown in Fig. 1, are, no doubt, the best ever invented, with limitations as to convenience and without limit as to cost.

These couplings are extensively employed in cotton mills in England and will continue to be, no doubt, not as many people suppose because the engineers who build the mills do not know better, but for other reasons, some of which we will name.

In the first place the cost, which is excessive, is not to be considered much in a cotton mill so long as there is something gained in safety from accidents and from risk of detention. To stop a cotton mill, either for spinning or weaving, is a serious matter. The loss is not so much one of time, but by derangement of the processes. If weaving or spinning machines are stopped with the warp in, or when the frames are being drawn, there is derangement of everything, threads broken, cloth spoiled and general chaos. The rule is that a mill "must not stop," and one of the most frequent causes of accident is found to be in the shaft couplings. This fact is not confined to cotton mills, because the same cause of detention is common in all factories, and is, perhaps, the most common of all, where long lines of shafting are employed.

The muff coupling, made of wrought-iron, bored with precision, and fastened by means of a long key extending the whole length and fitting into both shafts, gives absolute security in so far as driving. The truth of the work, and its endurance, is a matter of first cost and skill, and this, as before said, is not much considered in cotton mill gearing. There is the advantage of a smooth symmetrical contour so that nothing will catch on the coupling. This is another important matter in a cotton mill where women and children work, and in a country where the injury of any one has to be compensated by heavy damages. In this respect muff couplings are absolutely safe, because perfectly smooth. The keys are fitted by scraping, driven in and out until a perfect bearing is secured the whole length, then the ends are cut off flush.

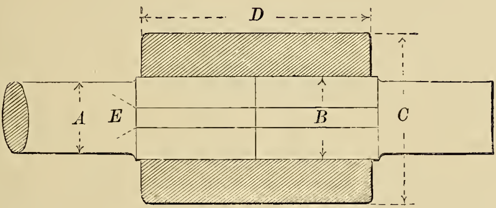


FIG. 1.

The ends of the shafts are enlarged, as the drawing shows. This too has its object, the shaft is not weakened by cutting the large key-ways required for the couplings, and there are no other key-ways required. The shafts, like the couplings, must be smooth, and key-ways of any kind are not permitted. Pulleys are made with their bore large enough to go over the enlarged ends of the shafts, and are fastened with conical bushes, or wedges rather, because the bush after being bored and turned true is slit up into six or eight parts for reasons that will be discussed further on. These keys are driven one at a time and equally, until the pulleys are so firmly fastened that they never come loose.

Here again is a reversion to first principles. This will be recognized as the old method of mounting wheels and

pulleys on polygonal shafts by keys or wedges driven at six, eight or more points around the shaft. With this much respecting the method of constructing muff couplings, and their objects, we will next consider their functions so as to compare them with other kinds of couplings to be hereafter considered.

It will be noticed that the same member, and with the same material, performs the double office of compression, or clamping, or resisting torsion, and supplying continuous rigidity, or an increased rigidity, to the shafts through the coupled joint. This is one of the generic functions, so to call it, of well designed shaft couplings. Other functions are ample torsional strength of the coupling itself, and complete smoothness of the exterior, also the facility of easy removal to either shaft, but not in this case, from the shafts altogether.

On the other hand we find a number of objections: First, and mainly, these couplings are not interchangeable, but must be specially fitted to a particular place, and are often fitted on short stubs to be welded to the shafts. Second, they cannot be removed or replaced without taking down the shaft. Thirdly, they are too expensive for an interchange system or for common use.

FLANGE COUPLINGS.

The next form to be noticed are flange couplings, such as are shown in end and section, Figures 2 and 3.

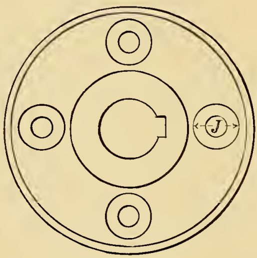


FIG. 2.

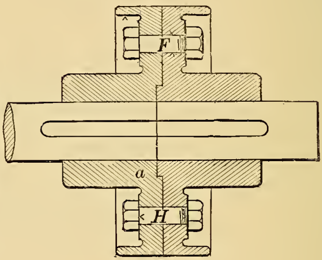


FIG. 3.

These are the most common, and are, in their nature, an integral part of the shafts to which they are fitted, consequently are not couplings except in the sense that they can be driven off and replaced in the same place, and if well fitted will run true after being several times removed and replaced.

In order to stand severe strain they must be trial fitted, that is, driven on and off and the high spots filed or scraped down. This destroys the truth of the faces, and these have to be, or should be, trued off after the coupling is keyed on. If the work is true enough to drive on the couplings without fitting, their faces will be thrown out of truth by driving the keys, which usually bear both ways and especially on the back, or radially, so that facing off is necessary in all cases if the shafts are to run true.

They weaken shafts by reducing their section for key-ways, and cannot be removed without taking down the shafts, because the keys are driven from the inner faces. We need hardly say that such couplings or flanges to connect shafts are not interchangeable, but constitute special machinery, and cannot be employed for an organized manufacture of line shafting. They are commonly employed because easy to make, or easy to be made true, by facing off, even if badly fitted, but mainly because so many kinds of interchangeable couplings are not strong enough, and cannot so well be made by common tools and

appliances. They do not belong in the organized manufacture of line shafting, consequently need not be farther considered here.

COMPOUND COUPLINGS.

It has been proposed, and some accuracy of fitting required would be the same or nearly the same, as in the case of solid flanges with the taper bushes added, and we need hardly say too expensive for common use. If the bushes are applied to one flange only, and the other keyed on, the shafts have

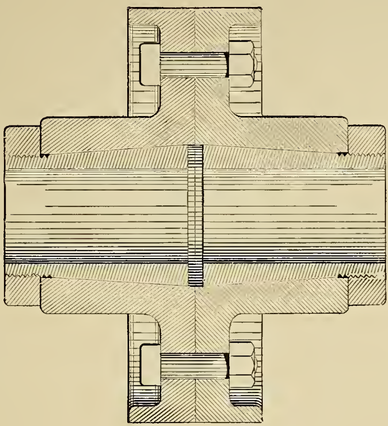


FIG. 4.

couplings of the flange kind have been made, with bushes, as shown in Fig. 4, having conical shells in one or both ends. This would make the couplings interchangeable, in a sense, but the to be shipped with the fixed flanges on the ends, and this makes awkward and risky work. In one case we know of, a railway company refused to receive such shafts as freight.

LEADING AMERICAN ENGINEERS.—CHARLES T. PORTER.

CHARLES T. PORTER, who is the eldest and only surviving son of the Hon. John Porter, an eminent lawyer, was born at Auburn, N. Y., January 18th, 1826. After graduating from Hamilton College in 1845, he studied law and was admitted to the bar in the fall of 1847. He practiced his profession first in Rochester and then in New York city.

After a few years he abandoned the legal profession for mechanical pursuits, and the study of laws which are uniform and certain in their operation. Some time later circumstances, joined to his own inclination, led him to devote himself especially to steam engineering.

On the 13th of July, 1859, he patented the central counterpoise governor for steam engines. In this governor the resistance from friction was practically eliminated, and the theoretical action of the "conical pendulum" was closely realized. No new principle was

involved or claimed, as the only aim of Mr. Porter was to obtain an action unimpeded by friction. His next patent, granted June 18th, 1861, was for an isochronous centrifugal governor for marine engines. This governor was new in principle. The resistance to the centrifugal force of revolving balls was furnished by a spring, to which was given such an amount of initial compression that its further compression, by the expansion of the balls, caused its resistance to increase in the same ratio in which the centrifugal force of the balls was increased by the enlargement of their circle of revolution. The two counteracting forces were, therefore, in equilibrium in every position of the balls, at a constant number of revolutions per minute. This principle has come into extensive use in governors which revolve about the axis of the engine shaft.

About the year 1860, Mr. Porter became associated with Mr. John F. Allen in the Porter-Allen engine. The valves and valve motion of this engine were wholly the invention of Mr. Allen, and were the earliest means by which an automatically varied expansion was obtained with valves having positive movements. All the constructive features which were for some time peculiar to this engine, but most of which are now in more or less general use, were designed by Mr. Porter.

He made an exhaustive study of the theoretical and practical conditions which are involved in the employment of high rotative speeds in stationary steam engines, and was the first manufacturer of these engines to employ such speeds with success. Conservative builders and power users looked with alarm on the bold advances in practice brought by an "outsider" into their chosen domain ; ridiculed his theories, and prophesied failure for their embodiment. The great danger attending such piston speeds was dwelt on by many who have since willingly yielded to the compulsion of competition in this matter. The impossibility of proper admission and exhaust under such conditions was urged by these same men, who at present claim and prove perfect steam distribution for engines at even higher piston speeds.

The "lawyer-engineer" was the first to point out the rate of acceleration and retardation of the velocity of the reciprocating parts of the steam engine, and the identity of the accelerating or retarding force with one of the rectangular components of centrifugal force :—the force required, at every point in the stroke, to produce such acceleration or retardation being represented by the cosine of the angle which at that point is formed by the crank with the line of centres. Mr. Porter also pointed out and practically demonstrated the value of this action, in equalizing throughout the stroke the pressure on the crank-pin in engines which cut off early, especially when this feature is combined with rapid rotation of the shaft.

In 1874, he published an essay on the use of the Richards indicator, "and the development and application of force in the steam engine," in which, among other things, the above described action was fully elucidated. In 1885, he published a volume of mechanico-philosophico-religious essays, under the title of "Mechanics and Faith: A Study of Spiritual Truth in Nature."

Mr. Porter was one of the organizers of the American Society of Mechanical Engineers, and was during several years a member of the Council. In January, 1888, he received a slight injury which was followed by a long period of nervous prostration. During his illness, the society, in May, 1890, conferred on him the distinction of honorary membership. He has since regained his health, and, impressed with the conviction that his work is not by any means finished, is now actively engaged in professional labor.

ECONOMY OF A NON-CONDENSING COMPOUND ENGINE.

By Prof. R. C. Carpenter, Sibley College, Cornell University.

SO many tests have been made of simple and compound condensing engines, that the relative economy of each class is well fixed, and it is known even in advance of a trial what may and should be expected. With the compound engine run non-condensing comparatively little has been done, and it is very much more difficult to obtain reliable figures representing the performance of this class of engines. The compound non-condensing engine cannot as yet be said to have its status fully established, and its economy as compared with a simple engine is a debatable question in the minds of most engineers.

While it may be some digression from my subject, yet as introductory to what I desire to state later, a few lines will be written on the methods of expressing the economy of an engine. As is doubtless well known, the performance of an engine may be rated by the weight of steam, of coal, or of heat units absorbed for each horse-power of work done. The most common standard and also the commercial one, is the coal consumed per horse-power per hour, but this is far from being a scientific one, since in this case the performance of the engine is made dependent on the boiler, and on the furnace, as well as on various other complex conditions; and it is entirely possible to use an excellent engine with a poor boiler and thus secure a poor showing. Engineers have been for some time accustomed to express the economy of an engine in terms of the number of pounds of dry steam consumed for each horse-power developed. This method gives the engine such benefit as there may be, in the heat held by the water entrained in the steam, since this water is deducted from the total in making up the report. The third method, that of expressing the economy in terms of the heat units absorbed per horse-power, has now numerous advocates, and is open to no serious objection, except the use of new terms which always accompany the introduction of a new standard. This method, which is certainly the most scientific and accurate, requires the knowledge of the heat supplied the engine, the heat exhausted and the indicated horse-power.

The consumption in heat units is obtained by dividing the difference between the heat that enters, and that which is exhausted, expressed in thermal units, by the total indicated horse-power.

The thermal unit is the amount of heat required to raise one pound of water from 39 degrees to 40 degrees Fahrenheit, and is termed a British Thermal Unit (B. T. U.). The number of heat units contained in each pound of steam may be found in any steam table, so that if the pressure of steam is known, and a steam table is convenient, there may be found the temperature of steam, its latent heat and its total heat —having these quantities we can readily determine the work performed in terms of the heat units as explained. The value of a heat unit in mechanical work was determined by Joule as 772 foot-pounds, but the later determinations of Rowland reduced to this latitude may be taken as 778 foot-pounds.

A horse-power is 33,000 foot-pounds per minute and is equivalent to 42.42 B. T. U. per minute or 2545 B. T. U. per hour.

From a thermodynamical standpoint the steam engine is a machine for converting the heat absorbed into work, and if this were done perfectly, a horse-power of work would be developed for 42.4 B. T. U. absorbed, and the efficiency of an engine would thus be deter-

mined by comparing the actual result with this number, but it will be noticed from the following table that with an increase of temperature and pressure of entering steam, a larger per cent. of the heat entering the engine becomes available, so that any statement of the performance of any engine would be imperfect were not the limits of pressure or temperature between which it worked mentioned.

Any engine may be considered perfect that transforms into work all the heat absorbed within the range of working temperature. Since the exhaust contains a large amount of heat it is seen that the efficiency of a perfect steam engine cannot of itself be high.

The theoretical efficiency of an engine is readily computed, and is useful in establishing a standard beyond which the economy of no engine can pass. It can readily be obtained from the temperature of incoming and outgoing steam; in each case it is equal to the difference of temperature of entering and exhaust steam divided by the absolute temperature of the entering steam. It will be noticed that according to this statement the efficiency is independent of the form or class of the engine and dependent only on the temperature of the entering and exhaust steam. Thus with steam of 100 pounds absolute pressure, its temperature is 327°.6 Fahrenheit, its absolute temperature 327°.6+460=787.°6. If exhausted at atmospheric pressure its temperature is 212 degrees, if at five pounds absolute, about ten pounds below atmosphere its temperature will be 162.°3 Fahrenheit.

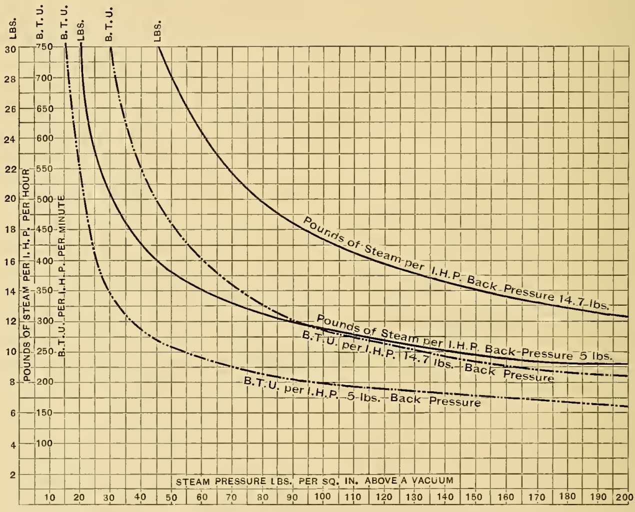


FIG. 1—ECONOMY CURVES OF A PERFECT ENGINE, NON-CONDENSING, ATMOSPHERIC BACK PRESSURE. ALSO CONDENSING, FIVE POUNDS BACK PRESSURE.

The efficiency in the first case is [327°.6 —212=115.6 divided by 787.6] 14.7 per cent.

Any engine which realizes in practice an efficiency equal to the thermodynamic, as stated above, is in this discussion termed a *perfect engine*. In such an engine the loss of heat is not due to any imperfection of the engine, but to natural limitations which govern the use of the working fluid employed.

The results which might be obtained with a perfect engine depend only on

the pressures of entering and exhaust steam, and are exhibited in the following table, for two cases, first, with the engine exhausting into the air, as run non-condensing, secondly, as exhausting into a condenser on which a vacuum of such an amount is maintained as to leave a back pressure on the engine of five pounds absolute.

A study of the table shows that the efficiency of the non-condensing engine for low steam pressures is very small, being for twenty-five pounds absolute (about ten above the atmosphere), only 2.6 per cent., but rising at 200 pounds absolute pressure to over twenty per cent. The condensing engine is comparatively much better at low pressures, but the gain due to use of the condenser is lessened at higher pressures.

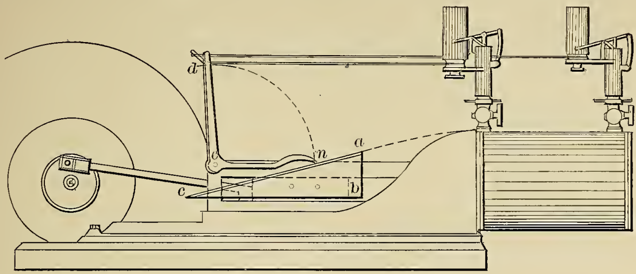


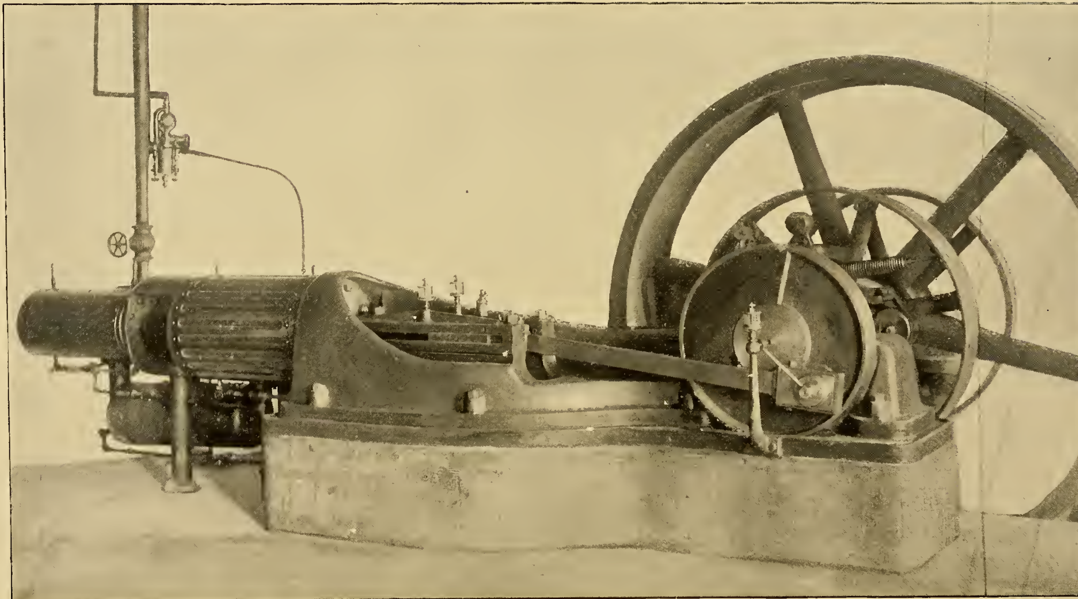
FIG. 2.—METHOD OF ATTACHING INDICATORS.

POUNDS OF DRY STEAM AND B. T. U. PER I. H. P. REQUIRED BY THE PERFECT ENGINE.

Steam Pressure. Absolute.	Temp. of Steam. Deg. Fah.	Back Pressure, 14.7 Lbs. [212°].			Back Pressure 5 Lbs [162.3°].		
		Thermal Efficiency. Per Cent.	B. T. U. Per I. H. P. Per Minute.	Dry Steam Per I. H. P. Per Hour.	Thermal Efficiency. Per Cent.	B. T. U. Per I. H. P. Per Minute.	Dry Steam Per I. H. P. Per Hour.
25	240	2.6	1620	100.05	10.9	388	22.8
30	250.3	5.35	740	48.8	12.4	340	20.0
40	267.1	7.55	560	34.2	14.7	287	16.8
50	280.9	9.2	465	28.0	15.95	266	15.4
60	292.5	10.55	400	24.0	17.25	245	14.2
70	302.7	11.8	364	21.8	18.4	230	13.2
75	307.4	12.4	340	20.6	18.9	224	12.85
80	311.8	12.95	328	19.7	19.5	217	12.5
90	320.0	13.85	306	18.3	20.5	206	11.85
100	327.6	14.7	288	17.3	21.1	200	11.5
125	344.1	16.4	259	15.5	22.7	187	10.7
150	358.2	17.85	240	14.1	24.0	177	9.9
175	370.6	19.1	221	13.0	25.1	169	9.55
200	381.7	20.2	208	12.4	26.2	162	9.20
		t	b	s	t	b	s

Formulæ: Let λ = total heat supplied,
q = heat (sensible) at back pressure,
T = absolute tempt. entering steam,
T_1 = " " discharge "

Then t = thermal efficiency $= (T - T_1) \div T$,
B. T. U. per I. H. P. per minute $= 42.42 \div t$.
Dry steam per I. H. P. per hour $= 25.45 \div t\,(\lambda - q)$.



TANDEM COMPOUND ENGINE, ON WHICH TEST WAS MADE, BUILT BY CLARK BROS., BELMONT, N. Y.

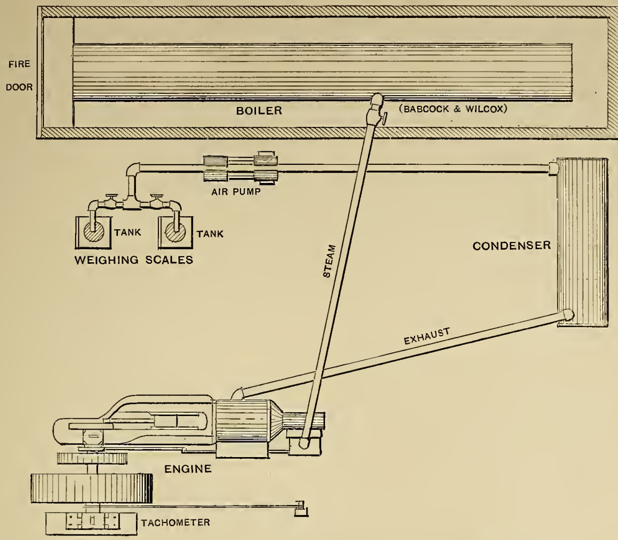


FIG 4.—PLAN SHOWING ARRANGEMENT FOR EFFICIENCY TEST.

The same results are shown in the diagram that follows: thus the heavy lines in Fig. 1 show the steam consumption in pounds per I. H. P. per hour for both the condensing and non-condensing engines, for various steam pressures. The diagram is of interest as showing at a glance the relative economy of the perfect engine when run condensing and non-condensing.

It shows that in both cases the economy increases with the pressure, but that for the higher steam pressures the curve for the non-condensing engine approaches that of the condensing. The dotted lines in the same diagram show the heat expenditures expressed in B. T. U. per minute. The curves are of the same general form as those for water consumption. From these curves can be learned much regarding the limits of the engine. Thus it is seen that with ninety-five pounds absolute (eighty by gauge) the best possible performance for the non-condensing engine is 17.8 pounds of water per I. H. P. per hour, and for the condensing engine with the same pressure it is 11.75 pounds. For 165 pounds absolute (150 by gauge) the steam consumption of the non-condensing engine is 13.4 pounds, that of the condensing engine is 9.6 pounds.

A lesson to be drawn is that the non-condensing engine with high pressure steam may have a performance that will compare well with the condensing engine under the same conditions, or in other words the per cent. of gain due to condensation is lessened by the use of high pressure steam.

It should be remembered that on the curves no allowance is made for the inevitable losses of heat which occur. These losses depend upon the class of engine and its individual construction, and are sufficient to increase the actual steam consumption from twenty-five to 250 per cent. over that shown as necessary for the perfect engine. The actual figures that may be expected for each class of engine has been shown by numerous trials to be about as follows:

Class of Engine.	Usual Steam Pressure by Gauge.	Pounds of Water Per I. H. P.
Small throttling, non-condensing	40– 60	40– 45
Small automatic, non-condensing	60– 80	37– 40
Medium automatic, non-condensing	80–100	31– 37
Corliss, simple, non-condensing	60– 80	30– 36
Corliss, simple, condensing	80–100	22– 27
Automatic, compound, condensing	100–125	16– 22
Corliss, compound, condensing	100–125	14– 20
Small direct acting steam pump	60– 80	150–400

The above figures are not given as the best results with engines of the classes named, but as those which can readily be secured in practice with fairly good management, the mean values being those which should be expected. A comparison of these figures with the preceding diagrams show that a part of the economy due to the use of the better engine is because of increased steam pressure.

These results differ very much from the theoretical values given, and the cause of this difference is to be found by first, the loss of heat caused by condensation on the inside of the cylinder, second, loss of heat by radiation, third, a load which does not give the best rate of expansion.

The loss by cylinder condensation is the great one, and is due to the fact that the cylinder walls at the closing of the exhaust valve are at the temperature of the exhaust, and must be heated to that of the entering steam at each stroke. This heat is derived from the steam and is a large amount, seldom falling in the single cylinder engine below forty per cent. of that supplied, and often rising to fifty and sixty per cent. This loss is lessened by using the steam in several cylinders, for the reason that the range of temperature through which each passes is less. It should also be noted that this loss is caused by the interior of the cylinder and is not lessened or changed by lagging, although it is affected by steam jackets or direct application of heat.

The problem of cylinder condensation is as yet not capable of exact statement in mathematical language, and it may not even be possible to state why a slight change of temperature in a large mass of metal should require less heat than a large change in a comparatively small mass of metal. That such is, however, the fact seems apparent by numerous trials, in every instance, if loading be favorable, the compound engine showing better results than the simple engine, even when working between the same limits of pressure.

Through the courtesy of Clark Bros. of Belmont, N. Y., the writer had the opportunity of making a test of a tandem compound engine run non-condensing, and the method of testing as well as the results will no doubt be of general interest and are given here in concise form.

The engine tested was a tandem compound with a shaft governor, and is illustrated in Fig. 2. Its principal dimensions were as follows :

	High Pressure.	Low Pressure.
Dia. cylinder, inches....	8	14
" piston rod, "	1½	1½ and 2⅛
Area piston, head end by inch..................	50.266	152.17
Area piston, crank end by inch........... ...	48.5	150.40
Engine constants for 100 rev. and one pound M. E. P., head...........	0.253	0.770
Engine constants for 100 rev. and one pound M. E. P., crank..........	0.242	0.757
Ratio of volumes displaced by piston......	1	3.11
Clearance..............	16.1	13.1
Ratio of volumes, including clearance.........	1	3.02

The apparatus used during the test consisted of four Crosby indicators, belonging to Sibley College, Cornell University ; a tachometer for indicating the speed, which was connected by a belt with the main shaft of the engine ; a throttling calorimeter, made as described in a recent book, Experimental Engineering, N. Y., J. Wiley & Son ; thermometer for temperature in the calorimeter ; pressure gauge and vac-

uum gauge. All the apparatus used was carefully compared with standards and the indications found substantially correct.

The reducing motion used was one often employed by the writer, and consists of a cam fastened to the cross-head and sliding under a "bell crank" lever, arranged as shown in Fig. 3. The construction will, I think, be clearly understood. *a*, *b*, *c* is a triangular cam fastened to the side or top of the cross-head as convenient; *n*, *e*, *d* is a bell crank lever pivoted at *e*, which is supported by the frame. As the cam *a*, *b*, *c* is moved back or forth under the bent lever, *n*, *e*, *d*, the point *n* rises and *d* moves horizontally. The indicator string is attached to *d*, which is of sufficient height to make the string horizontal. If *e*, *n* is made equal to *e*, *d*, *a*, *b* should be equivalent to the stroke of the indicator drum; *b*, *c* should be somewhat longer than the stroke of the engine. The arm, *e*, *d* should be vertical when *n* is at the centre of the slide *a*, *c*. The point *d* moves in the arc of a circle above *e* and for this reason the motion is not quite perfect, but the error is exceedingly slight and due entirely to the rise and fall of the point *d*; the horizontal motion is correct. The principal advantage of this motion depends upon the fact that first, the inertia effect is small; second, there is no disconnecting or connecting of indicator card throughout the test. When no cards are wanted the lever *d*, *e* is drawn back and fastened in such a position that the point *n* will not be in contact with the cam. When diagrams are wanted the lever *d*, *e* is released. The cutting and breaking and stretching of indicator cords being due principally to hooking and unhooking, this motion reduces the liability to accident in that respect, and permits very perfect diagrams. Third. This motion is especially satisfactory for high speed engines on a long test. Before the test was commenced the accuracy of the tachometer was fully established, the speed was adjusted by changing the size of the driving pulley until the reading agreed with the results by hand counting.

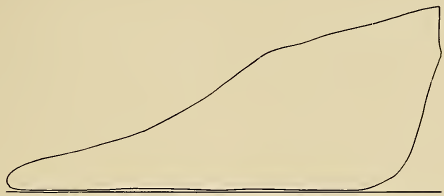


FIG. 5.—DIAGRAM TAKEN FROM ENGINE EXHAUSTING IN THE AIR, LOW PRESSURE CYLINDER.

FIG. 6.—DIAGRAM NO. 34. EXHAUSTING INTO CONDENSER ONE INCH VACUUM.

The engine was tested only in one

condition, viz., that of an ordinary non-condensing engine.

The general method of testing adopted was as follows :

Steam was supplied by a Babcock & Wilcox boiler, situated about twenty-five feet from the engine. The boiler was fed by an injector, but as wood was used as a fuel during a large portion of the test no attempt was made to obtain the efficiency of the boiler. Steam was maintained at a nearly constant pressure of 125 pounds throughout the test.

The general arrangement of the test is shown by the sketch in Fig. 4. The engine was set on a heavy foundation, where it could be used to drive the shop in case of necessity ; steam being supplied from the boiler and exhausted into a Wheeler surface condenser, to which was connected a small double acting pump in lieu of the regular air pump. Condensing water was supplied from an adjacent stream by the action of a heavy pump driven by water power.

The condensed steam was taken by the air pump and delivered alternately into two tanks standing on scales, one being emptying while the other was filling.

Indicator diagrams and readings were taken once in ten minutes throughout an entire day ; these observations included reading of thermometer in a throttling calorimeter, situated in main steam pipe a few feet above the engine, boiler gauge, condenser gauge, tachometer and speed indicator, and the water delivered from the pump. A preparatory signal was given about fifteen seconds in advance of the time for the observation, and a signal for the time of observation. At the latter signal indicator diagrams were taken simultaneously from each end of each cylinder, the water from the condenser delivered by the pump was transferred to the empty tank, and the water consumption for the period obtained. During the interim between observations the indicator diagrams were worked up, the horse-power of the engine ascertained, and also the steam used per indicated horse-power for that period. A set of indicator diagrams are shown in Fig. 8, with head and crank diagrams superimposed to save space. Each diagram was taken with a separate indicator.

It is not customary on engine tests to make measurements of water consumed at each observation, but the writer believes that such a practice adds very much to the accuracy of the results ; as it was found that in no case did the partial results obtained for a period of ten minutes differ more than three or four per cent. from the average of the entire test.

A principal portion of these results are fully shown on the graphical log Fig. 7.

It is noticed in this case that the steam from the engine was condensed in a surface condenser and delivered by the air-pump to the weighing tanks. This method renders it unnecessary to measure the feed water supplied the boiler and eliminates all sources of error due to leaky connections on the boiler, use of steam in the feed pump, and for other machinery. In this particular case it was impossible to divert all the steam to the engine, so that no other method was practicable.

The use of a surface condenser will in general permit more accurate methods than can possibly be obtained by measuring the water fed the boiler.

It was, however, in this case desirable to obtain the water consumption of the engine when exhausting into the air. An experiment was made to ascertain if the air pump could be driven so as to maintain the proper vacuum to overcome the resistance in the pipes and condenser. To determine this, an indicator diagram was taken when the engine was freely exhausting in the air ; such a diagram is shown in Fig. 5. The exhaust steam was then turned on the condenser and by a few trials it was found that a diagram with the same back pressure was produced when the vacuum gauge read one inch. A sample diagram for this condition is shown in Fig. 7. To maintain this vacuum constant, an air valve was arranged so that some air could be

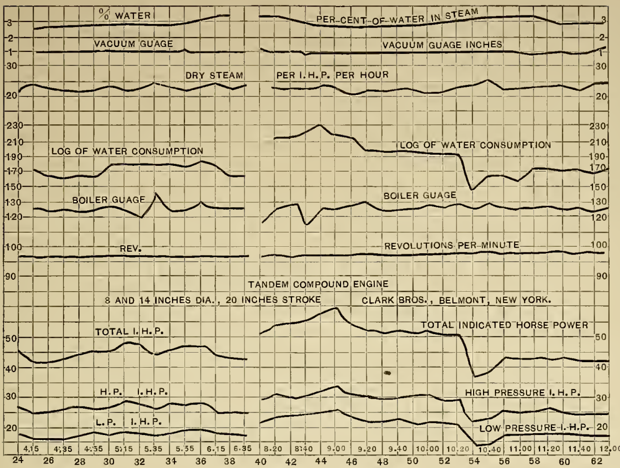


FIG. 7.—GRAPHIC LOG OF THE TEST.

"snifted" in at each stroke, after which, by adjustment of the speed of the pump, no difficulty was experienced in maintaining the required back pressure. A set of diagrams as taken during the test is shown in Fig. 8.

The load for the engine during the test was the machine shop belonging to Clark Bros. at Belmont, N. Y., supplemented by the addition of a large fan used by the foundry in melting iron. The load was not perfectly uniform, but the variation was gradual and capable of regulation to a limited extent. The average load was about 50 horse-power.

The details of log and result are all shown concisely on the graphical log, Fig. 7.

This diagram is worthy the closest scrutiny, the horizontal distances correspond to time and number of observation, the vertical distances have values corresponding to the numbers on the side, and show in order from the bottom. Indicated horse-power, developed first by the low-pressure cylinder, second by the high-pressure cylinder, third by the whole engine; in this case the numbers on the side denote the indicated horse-power. The next line shows the revolutions, which remained nearly constant at 97. The next line indicates the reading of the boiler gauge, which varied little from 125 pounds. The next line shows the total water consumption as measured in pounds for each interval of ten minutes. It is interesting to note how nearly this line maintains parallelism to the line showing total indicated horse-power. The next line shows the result of the test, or the consumption of dry steam per I. H. P. per hour. This is seen to be very nearly a straight line, averaging 22.6 pounds, corresponding to 547 British Thermal Units per minute.

The next line shows the reading of the vacuum gauge in inches, throughout the test, the top line shows the percentage of moisture in the steam as deduced from the calorimeter readings. Reading of barometer 28.8 inches is not shown on the diagram.

The results of the test show a consumption of 22.6 pounds of steam per hour or 547 B. T. U. per minute per I. H. P. and may be considered as establishing the fact that the compound

engine, even run non-condensing, will give an economy of steam and fuel much higher than that of a simple engine under the same conditions.* The gain in economy is no doubt hard to estimate from the fact that simple engines give such varying results, but if we take thirty-two pounds of water as the consumption of a simple engine per H. P. per hour, the gain is nearly one-third.

horse-power for less than three pounds of coal. As this evaporation is only moderate efficiency for a boiler, such an engine can reasonably be expected to develop a horse-power for less than three pounds of coal.

Finally attention should also be called to the slow speed at which the engine was run. So far as the writer knows this is the first test of an automatic

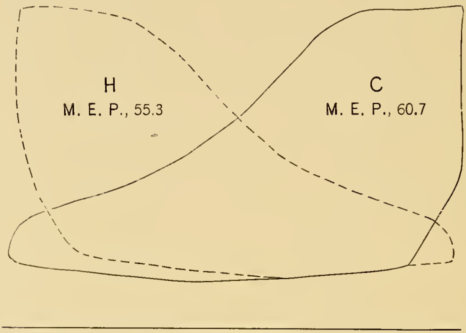


FIG. 8—HIGH PRESSURE CYLINDER. 60 SPRING. BOILER GAUGE, 125. REV. 97. BAROMETER 28.8 INCH.

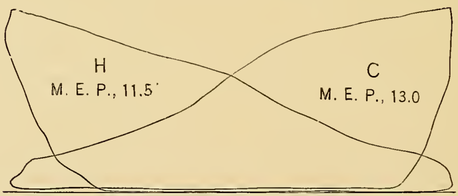


FIG. 9.—LOW PRESSURE CYLINDER. 20 SPRING. STEAM PER I. H. P. PER HOUR FROM DIAGRAM 17.9 LBS.

NOTE.—Figs. 8 and 9 are a set of diagrams taken from "Belmont" engine. Head and crank diagrams of each cylinder superimposed.

As it is frequently impossible to obtain water for condensing the steam, the question of the economy of compound engines under such conditions becomes one of great practical importance.

If an evaporation of eight pounds of water per pound of coal be assumed, this engine would have delivered a

engine at such speed. The test shows for such velocity better results than anticipated, for it is a well known fact that the engine wastes are less as the speeds increase. The results in this case are favorable to the low speed. One effect of the low speed, however, was to make the horse-power of the engine developed during the test very much less than its normal or rated capacity.

* See also report of a test of an engine of different construction made by the author at the last meeting of the American Society Mechanical Engineers.

The steam consumption calculated from the terminal pressure of the low pressure cylinders per I. H. P. per hour is 17.9 pounds, thus indicating that the diagram at release accounts for seventy-six per cent. of steam actually used. The consumption of steam for a perfect engine for the conditions under which the engine worked is seen by reference to Fig. 1, to be 14.6 pounds, which is 81.5 per cent. of that shown by the diagram and sixty-five per cent. of the actual consumption. The difference between the steam consumption for a perfect engine and that shown by the diagram is due first to loss of pressure in the cylinders, and second, to the condensation and re-evaporation which takes place as already described.

The tests would seem to indicate that a compound non-condensing engine with steam pressure of 110 to 125 pounds can be expected to develop a horse-power for a steam consumption of from twenty-two to twenty-four pounds per hour, or a fuel consumption from one-eighth to one-tenth the above amount.

Recent tests seem to indicate that the more economical the engine the less will be the variation in economy due to a change of load. This is also to be accounted for by the well known laws which govern the distribution of the waste heat in a steam engine cylinder. Thus of the total heat expended in producing work in the steam cylinder, a certain definite amount as shown in Fig. 1, is required to perform the work, while another portion is used to supply the wastes of the engine.

The wastes, by comparison with actual results, seem to vary with the square root of the load, while the other portion remains constant for each horse-power developed regardless of the work done.

By comparing the results obtained with various conditions of loading, I have found that the steam consumption for any horse-power can be expressed very nearly by the following methods: The steam consumption for any power waste per I. H. P.

$$\sqrt{\frac{\text{Rated horse-power}}{\text{given horse-power}}} + \text{a perfect engine as in Fig. 1.}\ \text{Consumption by}$$

To apply this to any practical case, we need to know the rated horse-power and the steam consumption when working at that power, thus in this case the rated horse-power is fifty, the actual steam used for I. H. P. is 22.6, that required by a perfect engine is 14.6, the amount used to overcome wastes is 8.0 pounds per I. H. P. To find the steam consumption for the engine when developing 12.5 horse-power we should have

$$8\sqrt{\frac{50}{12.5}} + 14.6 = 16 + 14.6 = 30.6 \text{ lbs.}$$

When developing twenty-five horse-power we should have

$$8\sqrt{\frac{50}{25}} + 14.6 = 11.2 + 14.6 = 25.8.$$

When developing sixty horse-power we should have

$$8\sqrt{\frac{60}{50}} + 14.6 = 8.75 + 14.6 = 23.35.$$

These results agree very closely with those actually obtained and serve to show that we are to expect less detrimental effect by sudden and great changes of load in highly economical engines than in wasteful ones.

ELECTRICAL TRANSMISSION OF POWER FOR MILLS.*

By C. J. H. Woodbury, Vice-Pres. Boston Mfrs. Mutual Fire Ins. Co.

EVERY one of the numerous applications of electricity, excepting incandescent lighting and chemical processes, as electro-plating, requires the use of electric motors; and some types of dynamos used for incandescent electric lighting contain a regulator which is operated by a motor. The telegraph receiver is a motor in which the electric impulses produced by the work at the operator's hands at the sending key converts the electricity from the batteries into work. In like manner, electric bells, watchmen's record clocks, railway signals, fire alarms, and even telephones, all are examples of motors. Mr. Edison once exhibited to me a telephone in which a small rod attached to the diaphragm of the receiving telephone was fitted with mechanism by which its rapid longitudinal vibration was converted into circular motion, causing a tiny wheel to revolve very rapidly.

The experiments of Barlow in 1826, by which an electro-magnet was used to cause a continuous revolution, gave rise to many ingenious inventions of devices for producing rotary motions by electricity; some of the experiments being on a large scale, so extensive, indeed, that a yacht was propellel by one fifty-four years ago, and a railway car forty-one years ago. All of these used the alternate attraction and release of an electro-magnet, giving a reciprocating motion to an armature, and this was easily converted into rotary motion. These devices obtained their electricity from batteries, and were comparable as a matter of principle to a device which might be made by attaching a tiny connecting rod and crank to a telegraph receiver. None of these early electric motors were of any practical value whatsoever in serving for motive power.

The electric motor which is the live issue of to-day is based on the principle that, while a dynamo will generate electricity if power is applied to revolve the armature, yet, on the other hand, if electricity is applied to the dynamo, the armature will revolve. The machine is reversible; and this reversibility has been wisely called by that eminent mechanician, the late Clerk Maxwell, the greatest invention of the century.

It undoubtedly resulted, as far as public attention was ever called to the matter, from a blunder of a workman engaged in putting up some electric lighting apparatus at the Vienna Exhibition in 1873, by which the wires were connected to one dynamo at one end and to another dynamo at the other end, and when one dynamo started, to the surprise of all, the other was set into rapid motion. As is usually the case with such inventions, there are others who allege that this well-attested incident was the result of design, to illustrate the discovery which they claim to have made previously.

It has been recently found that Dr. Antonio Pacinotti, the inventor of a magneto-electric machine, wrote a description of his machine in an Italian periodical in June, 1864, in which he says that it can be used to generate electricity, or as a motor; and he therefore is entitled to the credit for the invention of the present electric motor.

* Paper read before New England Cotton Manufacturers' Association.

The relation between magnetism and electricity, by which the magnet of an electric motor can set in revolution by its attraction the copper wires conducting electricity in the armature of an electric motor, is well illustrated by applying a magnet to an incandescent lamp. When the lamp is not illuminated the magnet will not produce any effect upon it, but if the lamp is in use the magnet will attract the filament.

The same machine can and has frequently been used at various times as a dynamo for electric lights and at other times for a motor; but there are numerous mechanical and electrical modifications essential to obtain the best results in an electric motor. The first use of an electric motor in any of the cotton-mills represented in this association occurred in a thread mill in Newark, where a dynamo was used in 1882 as a motor to run a lot of thread-winding machines.

Electric motors are now used for hundreds of purposes, but this paper will be confined to references to their uses in cotton-mills, and are frequently proportioned to use low-pressure currents of electricity, like those employed for direct incandescent lighting. There are many places where motors can be operated by wires from any of the direct incandescent lighting dynamos; but, if the power required for the motor is more than about one-fifth that required to keep the whole number of lamps lighted, the lights will rise and fall in brilliancy, like those in an electric car when the motor starts and stops, the lighting service is unsatisfactory and the life of the lamps diminished.

The problem is one which must be worked out in each case; sometimes, when a small motor is required for use at short intervals during the day, it might be the more economical to use conductors from a large dynamo which is already installed for lighting the mill at other times. If constant service is required from the motor, then a separate generating dynamo is advisable; and it may be said that in the generality of work it is preferable to put in a generator suitable for furnishing the current to the motors.

The principle holds as good in electric apparatus as in all other machinery, —that more satisfactory results are obtained when there is no attempt made to require a more varied service from any machine than it is fully adequate to furnish.

It is generally advisable to use electricity for the transmission of power at a much higher pressure than that found best suited to incandescent lamps, because there is a great saving in copper for conductors, and a lesser proportion of the electricity absorbed by the resistance of the wires.

The current of 500 volts' pressure used for the trolley system of street-car propulsion is not capable of inflicting serious injury upon mankind, although frequently fatal to horses. There have been motors suited for use on arc-lighting circuits, but I believe that at the present time there are not any of them on the market.

Before deciding to install an electric power plant for a service outside of what is already fixed by precedent, expense, delays and disappointment may be avoided by deciding how much you are willing to experiment; and, secondly, how much the party doing the work must experiment before the whole installation is in a practical operating condition.

The fact should not be lost sight of that electricity is merely a substitute for other methods of transmission of power. It has its losses at every step in the course, comparable with those of the wear and tear and friction of shafting and belting. Like them, it also costs money, requires attendance, and wears out. It does not in any detail give something for nothing, but the results in comparison with other mechanical means of the transmission of power are merely the addition of a lot of differences. Sometimes these differences are on one side of the account and sometimes on the other.

An installation of motors in one instance may be extremely economical and in another highly expensive, in comparison to ordinary methods of transmission of power.

Electric motors, like water-wheels or steam engines, have their highest efficiency at a point near to their full proper load, and on either side their efficiency in the percentage of electricity converted into work is diminished. The practical operation of some motors has been improved by the use of fly-wheels.

In its application for mill service, the most simple uses are those requiring a variable speed and direction, largely on account of causes outside of the electrical conditions in the construction of such motors. It is especially advantageous for elevators in storehouses or other buildings not requiring power elsewhere. A motor can be attached to any elevator machinery operated by a belt, and the elevator can be managed in the same manner as before, so that the men have nothing either to learn or to forget. The first motor used for operating an elevator in a cotton-mill storehouse was placed in that service in 1882, and is in as good working condition to-day. Another use having a larger field is in its application for railways in mill yards and buildings. The Salmon Falls Manufacturing Company has 2100 feet of track in the mill yard, and is operating a trolley system of cars to move all their cotton, supplies, cloth and coal, with two men, thereby dispensing with the services of a team and three men all of the time, and a fourth man a part of the time. The car makes an average speed of 600 feet per minute, and is always ready for service whenever the water-wheel is running. Other mills use electric railroads from the cloth room to the storehouse with even greater reduction in cost of moving the load.

There are two systems of overhead trolley propulsion; the ordinary single overhead wire, with the current returning through the wheels to the rails and thence back through the earth to the dynamo, is the simplest and the only one that has a practical system of switches in the wires overhead. This system contains a serious objection, in electric sparks constantly occurring in the contact of the wheels with the rails, and liable to ignite any combustible substance there, and therefore could not be safely used inside of mills. For inside use it is necessary to use the double overhead wire system by which the circuit is made between the two wires, without using the rails as conductors. In either case the overhead wires should be thoroughly protected by guard wires whenever there is a possibility of telephone or other wires falling upon them.

Electricity is filling a most useful purpose in operating traveling cranes, and the few storehouses in mills which are provided with traveling cranes use them at such infrequent intervals that it is probable that hand power is still the cheapest method of operation ; but for erecting shops, and other places where constant service is required, electricity affords great advantages for working such cranes.

Motors have been applied to calico-printing machines with great success. The absence of heat, small amount of space, little momentum of the revolving parts, and the control by which the machine can be uniformly moved in either direction at any desired speed, are all advantages of the highest practical value.

Other classes of work require that the motor should revolve at as uniform speed as can be obtained by a water-wheel, or better, if possible. Motors will revolve at a constant speed if furnished with a current of uniform pressure. A compound generator will produce a current at a uniform pressure with variations in the load or quantity of current required by the motors ; and it will also to some extent compensate for slight variations in the speed at which it is driven. Therefore it may be said that the speed of an electric motor may be more uniform than that of the water-wheel or engine from which it derives the power which it gives forth.

A variation in lights is not a direct measure of variation in a dynamo, because a change of one per cent. in the pressure of the electricity in an incandescent lighting system would cause a variation of several per cent. in the amount of light from the incandescent lamps.

The class of service for the distribution of power throughout a mill as a substitute for belt or rope transmission has not been tried in cotton-mills, but there are many cases where it has been tried in machine shops and yielded excellent results. The amount of power required in cotton-mills is so much greater than in machine shops that the subdivision should be to a smaller unit than a whole room in a large mill. I am convinced that such a distribution of power is mechanically feasible; but will it pay to do so when motors and generators each cost nearly or quite forty dollars per horse-power, or, including wire and foundations, over $100 for every horse-power transmitted?

Another class of applications consists in distributing the electricity from a central station in a mill yard to the various buildings. The most complete plant of this kind is at the Edison Works at Schenectady, where 1700 horse-power is electrically distributed to numerous shops situated at various places on a tract some twenty acres in extent.

The Thomson-Houston Works at Lynn have an extensive electrical distribution of power in their present works, and will have a larger power plant when their new works are completed.

At the Cumberland Mills in Maine 260 horse-power is transmitted over a mile by the Mather electric system, arranged by Messrs. Stone & Webster of the Massachusetts Electrical Engineering Company of Boston; and motors are used to drive paper machinery, giving from poorly governed water-wheels a sufficiently steady motion for calenders; but the compensation by the compound wound generators is not sufficient to remove the effect of all the variations of speed in the water-wheels from appearing in the motors; and these motors cannot run Fourdrinier paper machines, although motors in these mills deriving their power originally from a steam engine perform satisfactory work in driving paper machines. At these same mills an installation of motors is under way for the transmission of 1200 to 2000 horse-power for a distance of seven miles. As water-wheels give sufficiently uniform speed for looms, and as motors do give a more uniform speed, there is but little question as to their mechanical suitability for such work.

The third class of applications for electric motors is in connection with long-distance transmission of power, for the purpose of bringing the energy of a water privilege to a locality more convenient for manufacturing.

The problems of short-distance transmission, already considered, are as different from those involved in the transmission for a long distance as river navigation differs from that on the ocean; and the extent to which these long-distance problems have been mastered was shown by the transmission of 300 horse-power 109 miles, through No. 6 wire, at the Frankfort exhibition in Germany last year. There are power transmissions in California for mining machinery, for long distances, some of them being twenty-seven miles; but I am not aware that any such great distance has been applied for driving textile machinery.

The electric lighting and power used in Hartford, Conn., is derived in part from a water power at Tariffville, ten miles away, and some 300 horse-power is transmitted along the wire that distance, and thence distributed to customers around the city.

The Nonotuck Silk Company is supplying to its mills at Leeds and Haydenville, Mass., power transmitted by electricity from a dam in a rocky gorge in the river about a third of a mile from one mill, and a mile and three-quarters from the other. The installation is not cited as being on a large scale, but because it contains many ingenious features in the manner in which the motors are applied as an auxiliary and a regulator to the water-wheels. The fall of thirty feet is situated between steep banks, where it would not be developed under ordinary conditions, because the spot is unsuitable for the location of a mill. There are two water-wheels in use, one of ninety horse-power, driving

dynamos which furnish 950 incandescent lamps on an alternating system at the mills. The other 130 horse-power water-wheel drives one Thomson-Houston generator of eighty-five horse-power and another of thirty horse-power, the pressure of the current being the same as that used on trolley street cars. At the mills one-third of a mile distant is one motor of forty-five horse-power, two of twenty horse-power, and one of ten horse-power, all supplied by electricity from the eighty-five horse-power generator.

The forty-five horse-power motor belts upon the main shaft, which is driven by two water-wheels having a capacity of 100 horse-power under a twelve and one-half feet fall. The water-wheels are run at full gate without any regulator, but the motor serves as a regulator, running at uniform speed and furnishing the remainder of the power, which has a variable range of twenty-five horse-power. When the water falls too low for the water-wheels and motor to run the mill, a steam engine is belted to the main shaft, the motor and water-wheels furnishing their full capacity, and under these conditions the engine regulates the speed of the whole. It is an important precaution to set the governor on the engine for a speed slightly greater than its proportion to the motor and water-wheels, so that it will lead and also prevent the motor from tending to do more than its proper capacity. The other three motors are used to drive the machinery in an adjoining mill building, and they are connected directly to the shafting, one in each room. The fifty horse-power generator at the power station operates a forty-five horse-power motor in the mill at Haydenville, a mile and three-quarters distant. The arrangement of motor, turbines and engine is the same as at the lower factory, but placed in a more compact manner. Arrangements are being made for an increase in this electric plant.

For long distances it is essential to use electricity at high pressure in order to avoid the necessity of using large wires. For this purpose the electricity is generated in alternating pulsations, known as multiphase currents, at great pressure ; and, before entering the building where the motors are situated, the electrical pressure is reduced by a transformer, and in that condition used by the motors. Mr. Nikola Tesla of the Westinghouse Company is the inventor of this type of motors, which have been in practical use for some time in the shops of the Westinghouse Company at Pittsburgh. It is this type of multiphase machines which offers the only feasible means for transmission over distances exceeding a very few miles, without such undue losses as to be out of the question. These motors, being free from commutators or brushes, do not spark, are very compact, and easily start under a full load. Motors using multiphase currents are under construction by the General Electric Company.

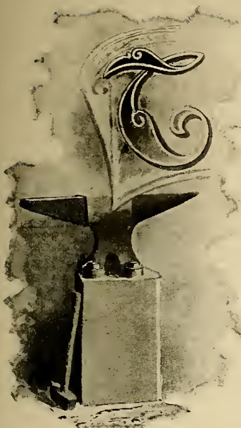
There are several places in New England where the power of waterfalls is being applied through electrical apparatus to machinery at a distance, and there are numerous extensive enterprises of this nature under construction.

The electric transmission of power under any practicable conditions of constant or variable speed, at a loss not exceeding twenty per cent., has been shown to be entirely practicable ; and the open question in regard to all of these devices, whatever may be their purpose, is but the question of cost.

It was my privilege, at a meeting of the New England Cotton Manufacturers' Association, held ten years ago, to present a paper on the subject of "Electric lighting in mills." The applications of electric illumination have grown during these ten years to such an extent that the daily manufacture of incandescent lamps in this country is now three times the whole number of incandescent lamps then in use in the United States, and I believe that there is no reason to question why there will not be in this decade a comparable increase in the applications of electricity to the transmission of power.

STEEL FOR FORGINGS.*

By Francis Rixson.



THE only material for engine and machine forgings before the invention of the Bessemer process of making steel, and for some time after, until confidence in that material was established, was fagotted iron, and notwithstanding its tendency to establish seams, and evident laminations, it served its purpose admirably, and even now, in the presence of mild steels of the highest excellence, an excellence far beyond the hopes of their several inventors, it continues to hold its own. For all difficult shapes where steel castings are not permissible, and where piecing up after partial machining is necessary, and, further, where "case-hardening" is called for, a good iron is essential, and will hold the field in its proper sphere.

Then, for the screw shafts of steamers and piston rods for steam hammers, iron lasts longer than steel, unless the latter are oil-tempered before using. An iron rod in one of our hammers was in constant use over thirteen years, and is now good, but kept as a duplicate. I never heard of a steel rod half that age; it will probably have made 7000 tons of steel forgings up to its replacement. Still, there are many purposes for which steel, carefully selected and judiciously adapted to the duty to be done, presents such features of excellence as no other known substance, commercially available at a reasonable price, can be said to possess; its uniform texture, its freedom from seams and impurities, its wearing properties, and the ease by which it can be tooled and polished, mark it out as the ideal metal for the moving parts of both heavy and light machinery.

There are several methods of making mild and other steels for mechanical and kindred purposes (and I purpose to-night to refrain from mentioning the crucible process, that subject having already been skilfully discussed in this room by able exponents of its merits), but for high-class work engineers and technical experts generally agree that the Siemens process is the one most reliable; its earlier sister process, the Bessemer method, to which the world owes much, not only to Sir Henry Bessemer, but also to Mushet, whose spiegeleisen made the blown, or decarbonized, metal malleable, but also to Heath and other workers, whose names do not often appear in the light they deserve. Where quantity is the first consideration, the Bessemer process is vastly superior, but where nice gradations of temper and quality are imperative, the Siemens is indispensable, as frequent tests can be taken and variations made in the composition, until the exact point is reached which the specification being worked to calls for. There is also the more recently developed basic process both in Siemens and Bessemer practice, but as those yield a class of material for constructive and commoner purposes, they do not fall within the scope of these remarks.

The steel best adapted for forgings, such as piston rods of engines, main engine shafts, marine cranks, and other

*Paper read before the Leeds (Eng.) Association of Engineers.

parts subject to severe torsional strains and carrying heavy loads, should be of such a nature as to give a tensile stress of twenty-seven to thirty tons per square inch, with a high percentage of elongation, say thirty-five per cent. in two inch, and a reduction of area of, say, forty-five to fifty-five per cent. A bending test one inch square, ten inches long, should bear bending over a round bar 1¼ inch diameter and it should bear closing thus ⊂ and show no signs of fracture. For special cranks for high-speed engines a steel of higher tensile strength is desirable, and thirty-four tons tensile, twenty-eight per cent. elongation, and fifty-two per cent. reduction gives excellent results, especially when used in white metal bearings; it never licks up the metal.

It is not necessary to define the chemical composition of an ideal forge steel, as good results can be, and are, produced by different methods; but I prefer a stiff steel of good quality to a soft steel of low character, and I always question the judgment of engineers who stipulate that their forgings should be made of steel under .15 carbon. My own opinion is that about .30 is better in every way, and is certainly more free from blemishes than the softer grades of material. Perhaps the best proof of this is to be found in the punishment or fatigue test, described at the end of this paper, a test which leaves no doubt of the capacity of the material to resist such shocks as may be expected in use.

The falling test is one on which public engineers rely almost as much as on the tensile test. Select a forged steel bar, say 3½ inch diameter and five feet long, place it on supports three feet apart, drop a tup of 1120 pounds on it from a height of twenty feet, continue the blows until an angle of ninety degrees is reached, then press the ends towards each other until this curve is reached ⊂ without fracture. A railway axle of the usual shape, 4½ inch diameter in the middle, bore six blows of twenty feet each, from a tup 1650 pounds, without breaking; and a further blow of thirty-eight feet broke it. Another axle, 4¼ inch diameter, bore six blows of twenty feet and eleven blows of forty feet without breaking; after this seventeenth blow (it being warm from concussion) it was cooled in ice and snow, and broke at the eighteenth blow—and no wonder. An iron axle was next tested, 4⅝ inch diameter. The test specified was six blows from twenty-five feet. It broke at the fourth blow, showing a coarse, dirty fracture. A steel axle, same size, bore six blows of twenty-five feet, and also twenty blows of forty feet. These particulars show the wonderful tenacity of a good steel forging, and when it is remembered that good steel is cheaper than good iron, the difference in strength, as an equivalent of money, is the more remarkable.

As a result of excessive vibration, iron and steel are liable to "tire," and become flaky or granular; and the late Mr. Robert Hadfield once showed me a bar of iron which had been subject to some thousands of sharp blows—a piece was easily broken from the 1½ inch round bar by a hand hammer. The flakes were something like the scales of a roach. The other piece of the bar had been re-heated, and thrown down to cool, and its fracture was fibrous, like an ordinary piece of new iron. Before leaving the question of material, I may say that Siemens steel is now being made from .09 carbon up to 1.50 per cent. The latter is used for fine files with great success, whilst tempers of .75 to .95 make wonderfully good saws and springs; indeed, so successful has this become, that common crucible steel is a thing of the past.

And now, having described the nature and quality of the material for forgings, a word as to treatment. Much depends upon the manner in which the heating or furnacing is carried on. The heating should never be rapid; time should always be given for thorough soaking through, or wasters are a certainty; and you all know how disappointing it is, sometimes disastrous, to find days and sometimes weeks of turning are lost by a flaw appearing just when the job is apparently done. Hammering should never be too rash at first; it segregates the particles and weakens the piece.

On the other hand, cold hammering is objectionable, as tending to brittleness. Steel so treated needs to be, and ought to be, annealed, as also should all forgings made in bosses or dies to exact shapes, else, when at work, they are liable to expand and fret their bearings.

There is another method of making forgings, which has budded and faded more than once, to which reference may be made, viz., the use of piled scrap steel, which is fagotted into blooms, reheated and swaged. The process was first applied at Dumbarton, later by the Mersey Forge, who rolled down ingots into flat slabs, and piled and welded them for cranks and other important work. Railway companies also use this plan for side rods, draw bars, etc.; the resulting forgings ring under a stroke of a hand hammer, same as steel, but a fracture looks like iron. I do not approve the use of this process generally, believing the forgings would be affected by extreme frost, and be, in consequence, dangerous, especially for drawbar hooks, on account of the sharp snatches they have to endure. I think it best to pass the steel plate scrap through the Siemens furnace and use new ingots.

In connection with this subject I may allude to the importance of the drop stamp for producing small forgings in large quantities. The saving over hand-made articles is remarkable, but not more remarkable than the greater excellence of the product. The principal factor in this process is the dies, which must be made of very good material and exact workmanship. The next point to observe is the selection of a good soft material, which will bear forcing into the desired form, without breaking up; and a most important feature is that the guides are true, or the trimming after the stamp will be very troublesome. It sometimes happens in the manufacture of important steel forgings that, in spite of great care, internal defects will exist in the interior of the piece. These defects are generally to be traced to the existence of gas or air bubbles in the ingot, which hammering and rolling do not remove, but usually aggravate, by driving the occluded gas in various directions. Now, this subject has occupied the minds of several good metallurgists, but the remedy is, in the main, as far off as ever. Whitworth employed the hydraulic pressure on the fluid steel as a remedy, but it is extremely expensive in practice, and has not been generally followed.

Another branch of the business of forging is that known as bending prepared bars of forged steel or iron into bent cranks by using the hydraulic press. It means a great saving of time and labor, and when numbers of a given type and size are called for, and a powerful steam stamp associated with the press, cranks of the best shape and finish can be produced at very low prices, the principal outlet being in the direction of portable and kindred engines and for gas engines. This process was first employed only for the manufacture of cranks having a sound section, but since 1884 the firm of which I am a member turned their attention to making bent cranks, having the same configuration as forged slab cranks, at the same time providing for the fibre of the material to be continuous throughout the piece, and at the same time to avoid the delay and labor inseparable from the drilling and slotting of slab cranks. This process is now in daily operation for locomotive and electric lighting engines, and also for marine and mill engines, and is giving great satisfaction.

It may be said that wonderful mileage has been got out of locomotive axles by the older method; indeed, recent cases have come under my observation showing 750,000 miles run; but it is very frequently the case that new axles go in their first year, and in many cases the causes are due to want of work on the vital parts. Numerous "cripples" recently examined show fractures on the underside of the crank pin, the next in order show weakness on the inside web, and others fail from the strain of twisting by wrenching the webs from a straight line to right angles at the forge. I ought to speak cautiously at Leeds on this subject, but I

am convinced that the present practice of locomotive crank axle making is wasteful, clumsy, and expensive, giving the worst results at the maximum expense.

Intimately connected with steel forgings is the practice of tempering in oil, in order to increase the toughness of the article so treated. Locomotive axles are often oil-tempered, as are the inner tubes and trunnions of large guns, while smaller guns are heated entire and quenched vertically in a bath of oil, the oil vat being itself immersed in cold water, sometimes artificially cooled, so as to keep the oil at proper temperature. Steel, which in its normal state will bear a maximum load of 31 tons, will, after heating and quenching in oil, carry 43 tons tensile, and gun barrels after such treatment are reheated sufficiently to reduce the tensile to 37 tons, which gives excellent practical results. In this state the metal works very sweetly. I recently saw a turning, 268 feet long, taken from an oil-tempered steel gun barrel. Where high results are desired, and price no object, the oil tempering is a very good thing, but, like other good things, it costs money.

Another subject in connection with forgings is that of the proper allowance for tooling. This is a question on which all the doctors differ, and can best be solved by the application of a little common sense. Engineers will ask for three-sixteenths on a double crank, and others will allow half an inch on a plain bar of similar size. Both are wrong ; a very good rule for articles having but one setting is to allow one-quarter inch up to five inches in diameter, three-eighths for six-inch, seven-inch and eight-inch, one half-inch for ten inch, and one inch for one foot. Most turners will agree that an allowance sufficient to clean up the forging all over is more easily dealt with than a closely forged shaft, which has to be humored in the lathe, and requiring its centres altering several times. Given a good lathe, a good man, and a straight forging, no one need complain if an extra eighth has been left on by the forgeman.

FATIGUE TESTS ON CRANK STEEL.

A piece of the steel planed out of the solid, 1¼-inch square and 12-inch long, is placed upon supports 6 inches apart, and a tup weighing 1120 pounds is dropped from a height of one foot upon the specimen, and the piece turned over after each blow.

Mark on specimen.	Description of material.	Maxim tensile per square inch.	Elongation per cent. in 2 inches.	Reduction of area per cent.	No. of blows before distress.	Total No. of blows.	Remarks.
25	Ordinary forging steel..............	29.0	35.22	53.50	23	25	Deflected freely under drop.
45	Admiralty crank steel..............	27.3	31.50	52.40	39	45	Ditto.
57	Fluid compressed steel..............	33.65	33.00	58.50	49	57	Ditto.
78	Special W. & R. crank steel........	34.00	33.00	56.80	73	78	Deflection much less than the others.

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Fourth Paper.

THAT

"Tide in the affairs of men
Which, taken at the flood, leads on to fortune,
Omitted, all the voyage of their life
Is bound in shallows and in miseries,"

had set in for Edison's storm-tossed craft, and a steady gale blew from the Blessed Isles, wafting the adventurer into all tempting harbors of successful discovery.

"Enterprises of great pith and moment" filled Edison's restless brain and gave employment to his tireless energies, but the financial basis was not as liberal as in the days of Mr. Laws' personal management, and, as the inventor humorously remarked: "I got tired doing all the work of the firm with a compensation narrowed down to the point of extinguishment by the superior business abilities of my partners." He therefore retired from the firm and connected himself with General Marshall Lefferts, then president of the Gold and Stock Telegraph Company. The facilities furnished by General Lefferts led Edison to the invention of a host of stock printers and private printing telegraphic appliances, which commended themselves so entirely to the company that they appointed a committee to wait upon Edison, with a view to securing the title of these inventions. Edison's dealings with that august body are best told in his own words. "I had made up my mind that five thousand dollars would be about right, although other people were paid exorbitant prices for very inferior inventions, but rather than not sell the inventions, I would take anything, no matter what, as I needed money sorely for my further experiments. With these dazzling expectations I received the committee."

"Well, Mr. Edison," said one of the members, "how much do you want for your devices?"

"I do not know what they are worth," was my reply. "Make me an offer."

"Well," continued the speaker, "How would forty thousand dollars strike you?"

"I believe I could have been knocked down with the traditional feather, so astonished was I at the sum. I immediately accepted, but after I got over my excitement, I concluded there must be some Wall street trick about this thing. I had been reading about Wall street tricks for years, and thinking this was one of them, I concluded that if I ever got a cent, I would be lucky. However, I was anxious to see the process worked out, so two days afterward, a large, formidable contract was given me to sign, couched in phraseology as obscure to me as Choctaw. I was told that I would receive the money upon signing this, which I promptly did, after which a check was given me on a bank on William and Wall street, to which goal I at once proceeded. I had never been in a bank before, so I hung around in order to see the methods of procedure, then took my place with a row

* Began in November issue.

of boys at the paying-teller's window. When my turn came and I presented the check, the paying teller yelled out a lot of jargon, which I failed to understand on account of my deafness. Again he roared something at me, but I could not catch it, so left my place and passed on. Sitting dismally on the steps of the bank, I concluded that I was never fated to see that money, and so hopeless did I become that anyone might have bought that check from me for fifty dollars. However, I went back and told one of the clerks in the company's office about the bank episode, when he explained that the teller evidently wanted me to be identified. He then went back to the bank with me, performed the ceremony of identification, and the money was at once paid, greatly to my astonishment. In thirty days I had fully equipped a shop of my own, an investment which left me very little money.''

Several of these minor shops were successively occupied by Mr. Edison, and despite the paucity of space, and the limited appliances, much valuable work was accomplished.

''From these establishments,'' continues Mr. Edison, ''a large number of inventions were turned out, the majority relating to printing telegraphs, after which I became associated with a party of capitalists, who formed the Automatic Telegraph Company, owning the inventions of a Mr. Little, for which great claims were made, but which upon actual trial were found inoperative, leaving the company in a quandary. They had constructed a line between New York City and Washington, firstly for experimental purposes and secondly for real business, but the latter could not be carried out on account of the failure of Mr. Little's apparatus. I was called in at this juncture and solved the problem in such a manner as to open the line for business.''

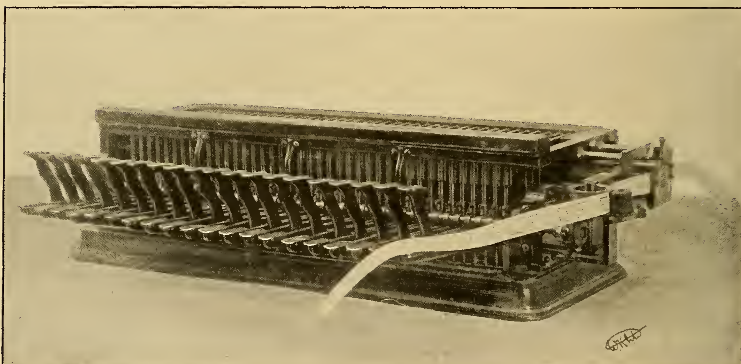


FIG. I.—ROMAN LETTER PERFORATOR FOR EDISON AUTOMATIC TELEGRAPH.

Edison was rapidly rising in the esteem of his employers. The retention of his services by the Western Union Telegraph Company, in addition to the demands made by the Gold Stock and other influential firms, made it imperative for him to secure a wider field of action and a larger force of subordinates. In the year 1873 he therefore entered into an agreement with the Western Union and Gold Stock Company, which pledged him to the development of all ideas relating to telegraphy. A handsome salary was paid him, and he was under contract, at very high rates, to concede to the companies the

AFTER A PHOTOGRAPH BY W. K. L. DICKSON.

EDISON CAUGHT AT WORK IN HIS ORANGE LABORATORY.

exclusive option on all telegraphic inventions.

The establishment was wholly unpretentious and devoid of architectural beauty, but it was centrally located in Ward street, Newark, supplied with a comparative abundance of facilities and manned by a force of three hundred.

The general arrangements of the new enterprise were, to say the least, peculiar.

"I kept only pay-roll accounts," says Mr. Edison, "no other kind, preserved the bills and generally gave notes in payment. The first intimation that a note was due was the protest, after which I had to hustle around and raise the money. This saved the humbuggery of bookkeeping, which I never understood, and the arrangement possessed besides the advantage of being cheaper, as the protest fees were only one dollar and fifty cents. Notwithstanding this extraordinary method of doing business, every one was willing to accept the notes, and my credit was excellent during the years I occupied Ward street factory."

Mr. Edison's intolerance of the "humbuggery of bookkeeping" probably arose in part from the fact that in the early stages of Ward street factory that majestic establishment boasted the services of a bookkeeper, the sensational statements of whom were calculated to keep the working force alternating between rapture and despair. This gifted individual, winding up the books at the end of the first twelve months, discovered, or thought he discovered, a handsome surplus of $7500, and presented himself before his chief with that pleasing information. Edison was naturally delighted at the outcome of their first year's enterprise, and by way of celebrating the event gave orders that the boys should have a "rousing jamboree" at his expense. Before the order could be carried into effect, however, he began to experience a certain sense of insecurity based upon the knowledge of his late serious expenditure, in connection with the fitting up the factory and the prosecution of innumerable scientific projects. He therefore determined to look into the books himself, and, after a night of exhaustive study, possessed himself of the paralyzing fact that instead of a surplus of $7500, the accounts showed a deficit of fifteen thousand, some odd dollars. It is needless to say that the order for festivities was abruptly countermanded.

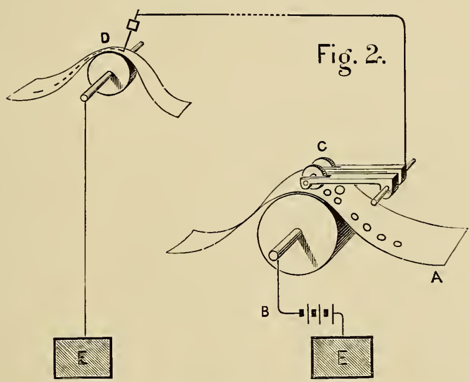


FIG. 2.—DIAGRAM SHOWING THE PRINCIPLE OF THE SENDING AND RECEIVING APPARATUS, EDISON AUTOMATIC TELEGRAPH SYSTEM.

The hours of work were as erratic as

the finances, and must have resulted in utter anarchy and confusion, but for the prevailing spirit of affectionate co-operation which existed. The sunny enthusiasm which had stood Edison in such excellent stead during the years of his servitude acted magically now upon his subordinates and promoted an atmosphere of cheery perseverance very different from the sluggish and enforced activity too often noticeable in other establishments. The master-mind was discernible in the most insignificant details ; the master-hand was at the disposal of the humblest mechanic. By example, by precept, by judicious incentives and by general companionship Edison kept the public interest sustained and received the willing co-operation of his employees. "We had no fixed hours," says Mr. Edison, "but the men, so far from objecting to the irregularity, often begged to be allowed to return and complete certain experiments upon which they knew my heart was especially set."

There were times when Edison's joyous nature completely bubbled over, and swept all before it in a tide of boyish hilarity. On one of these occasions he returned to the Newark factory, after a successful trip to New York, where he had been fortunate enough to dispose advantageously of a pet invention. Entering the workshop with a whoop, he fired his silk hat into an oil pan, and was preparing to send his coat after it, when some one laughingly pinned him down, and relieved him of his impediment. Whenever an experiment of unusual importance was on hand, and it was necessary to rush it through in a given length of time, Edison was wont to go through the laboratory, scattering largesse with liberal hand, and inciting the men to fresh endeavor by humorous bets as to their incapacity. This invariably put the men on their mettle

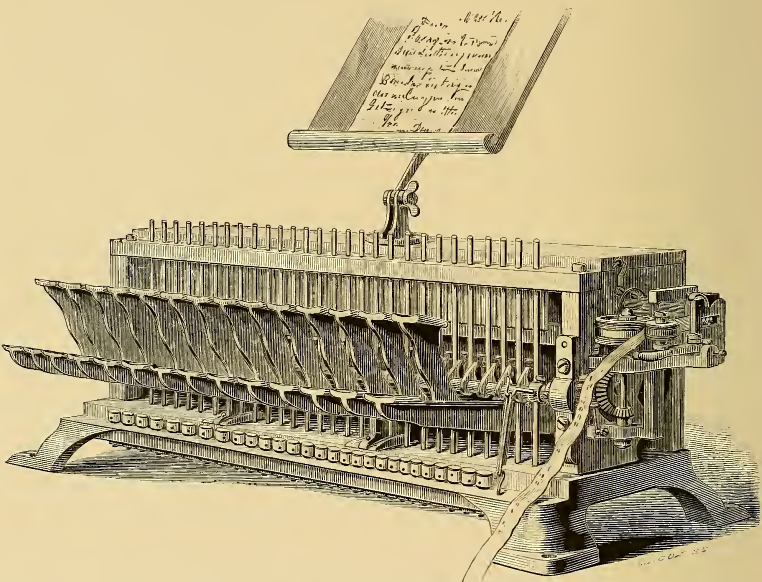


FIG. 3.—ROMAN LETTER PERFORATOR FOR EDISON AUTOMATIC TELEGRAPH.

EDISON LABORATORY AND FACTORY IN NEWARK, 1873.

and brought out their utmost speed and skill.

The engrossing nature of his occupations may be inferred from the following amusing episode :

"I had a number of schemes fermenting in my brain," says Mr. Edison, "foremost among which was the Quadruplex telegraph. This problem was of the most difficult and complicated kind, and I bent all my energies toward its solution. It required a peculiar effort of the mind, such as the imagining of eight different things moving simultaneously on a mental plane, without any external mechanism to demonstrate its efficiency." While engaged upon these complex themes Edison was notified with legal abruptness, that unless he paid his taxes the next day (the last of a term of grace) he would be compelled to pay twelve and a-half per cent. extra.

In compliance with this stern demand he repaired to the city hall and took his place at the end of the line with about one hundred ahead of him. During the tedious delay which followed while awaiting his turn, Edison had been working on that brain-dividing problem, the Quadruplex telegraph, and had become totally abstracted from the matter which brought him to the tax office. The last moments of grace were almost at an end when Edison found himself in front of the implacable Rhadamanthus in charge, who gruffly said, "Now, then, young man, look sharp. What is your name?" "I had lost my composure completely," remarks Mr. Edison, "and all recollection as to my name as well, for I stared at the official behind the counter in blank perplexity and answered, 'I—I don't know.' Jumping to the conclusion, I suppose, that he had an

idiot to deal with, the tax collector waved me impatiently aside. Others poured into my place, the fatal hour struck, and I found myself saddled with an extra charge of twelve and a-half per cent.''

Coeval with the first development of the Quadruplex and with the final completion of the Gold Stock Printer was the completion of Edison's Automatic Telegraph, a machine designed to render telegraphy wholly independent of human manipulation. Many important inventions of this class were in the field, notably those conceived by Alexander Bain, Sir Charles Wheatstone, Lefferts, Hummaston, Bradley, Craig, Little, and others, but the methods were comparatively cumbersome, and the speed insufficient. The inventors were baffled by a multitude of puzzling phenomena, and hampered by the difficulties attendant upon a swift preparation of the paper, and the control of the electrical currents. In 1870, as has been stated, Edison completed an apparatus by which the rapid preparation of the paper was achieved, and perfected auxiliary machinery for the transmission and reception of the messages. A year later, his efforts were rewarded by the discovery of the laws governing electrical waves, propelled at rapid speed over long distances, and applying the principle of inductive compensation to the waves, he secured to these subtle agents a velocity unequaled in scientific annals.

The Edison Automatic Telegraph System is comprised of three machines, one for perforating the paper strip in Morse characters, one for transmitting the messages, and one for receiving them. The first machine, or perforator, Morse signs, is capable of punching out fifty or more words a minute. A long strip is run through the second machine, or transmitter, consisting of a drum, revolving at a uniform speed, and connected directly with the main telegraph line. The perforated strip is carried over the drum and the circuit is completed through metallic points, connected to the battery and the earth. The pens reaching through the perforations send a series of impulses over the line, making contact with the metal drum, and so registering at the other end upon chemical paper, and by means of electro-chemical decomposition, a series of short and long dashes of a dark blue color, exactly similar to the punched characters at the sending station. The receiving strip of chemical paper is placed upon a registering metal drum, the pointers of which are in readiness to transmit every impulse to the surface of the paper. The Automatic Telegraph is as simple as the Quadruplex is complicated, and its capacity may be indefinitely increased by the addition of extra perforators.

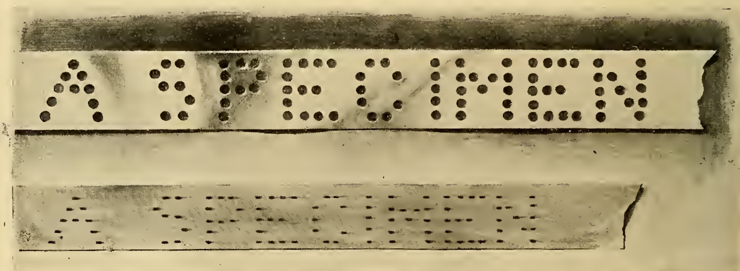


FIG. 4.—THE UPPER IS THE SENDING AND THE LOWER THE RECEIVING STRIPS. EDISON AUTOMATIC TELEGRAPH SYSTEM.

The Automatic Telegraph Company of New York were not slow in acquiring the patents covering this marvelous invention, and the system was ex-

tensively utilized. A leading periodical, as early as 1873, speaks of the Edison Automatic Telegraph System as "simply incredible," and gives some interesting details of the speed already attained. "The dispatches of the Press Association from New York and Philadelphia to Washington are sent at the rate of 1000 words per minute in all conditions of the weather, which seriously affects other systems. Between New York and Pittsburgh 800 words are sent, and between New York and Charleston, S. C., a distance by wire of 1050 miles, messages are transmitted at the rate of 300 words per minute, a wire which neither the Morse nor House-Hughes can practically work direct.

It will be seen that the capacity of one wire between New York and Washington is nearly equal to the total mail correspondence between those two centres." We give these early statistics to show how radical was the reform effected even at that comparatively immature stage, and how prompt was its adoption by the unbiased and enlightened portion of the community.

From the larger facilities afforded by his new premises Edison continued to perfect all the mechanism connected with automatic telegraphy. He also devised a Roman letter system of chemical telegraphy, which he transmitted from Philadelphia and recorded in New York city over three wires to the prodigious number of 7000 words a minute.

The perforating machine for this system is operated very much like a good-sized typewriter, having a key for each letter of the alphabet, as well as extra keys for signs and numerals. Additional numbers of metallic points are used in transmitting and receiving, with this exception, the Roman letter and Morse signs are the same.

It was while experimenting upon chemical telegraphy that Edison was led to the discovery of the electro-motograph, that is, of its embryotic principles, for the semi-perfected form of the invention was only evolved after six years of severe and persistent study, and the system, according to the inventor, still admits of improvements. The discovery is based upon the fact that "certain chemical salts lose their functional properties when subjected to the action of an electric current." By accepting this principle as a starting point, we have a system of chemical telegraphy in which it is possible to dispense with the ordinary relay magnet, a system in which friction and anti-friction are utilized in place of the magnetic power embodied in the relay. Although actuated by an almost inappreciable current, its power of speed is at least ten times that of any magnet in the

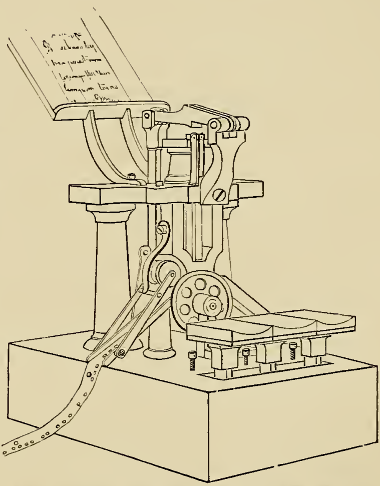


FIG. 5.—MORSE PERFORATING MACHINE FOR EDISON AUTOMATIC TELEGRAPH.

scientific field, and it is the only instrument susceptible of repeating or translating from one circuit to another the signals of high speed telegraphic systems. But let us enter somewhat more closely into the technical construction of this apparatus. A chalk cylinder, saturated with a salt of mercury and a strong solution of caustic alkali is made to revolve at regular speed by turning a crank. One end of a strip of paladium-tipped brass is held against the chalk cylinder by means of a spring, the

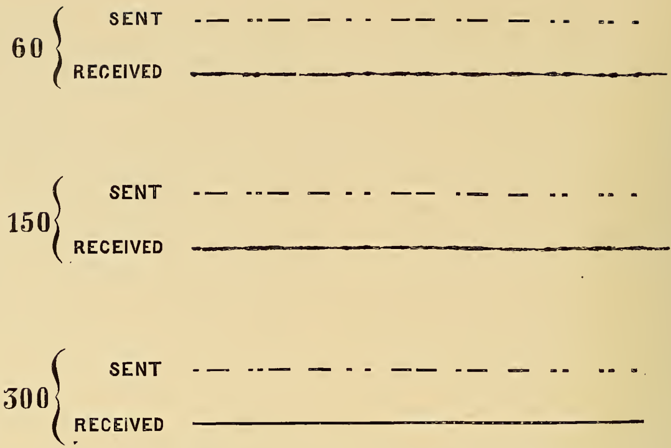


FIG. 6.—EFFECT OF STATIC DISCHARGE UPON SIGNALS AT DIFFERENT RATES OF SPEED PER MINUTE.

other end of the strip being hinged to the centre of a mica diaphragm, which in its turn is secured rigidly in a suitable frame. On turning the crank away from the diaphragm, the pressure or friction of the strip, bearing against the chalk, tends to draw the diaphragm in. Should the friction be suddenly lessened, a loud noise would be the result, caused by the diaphragm springing back into position. Therefore, as we have seen, the electro-chemical decomposition of the prepared chalk and its resultant smoothness are in proportion to the greater or lesser force of the electric waves transmitted, in obedience to the impulse of the human voice, through the distant Edison carbon-telephone transmitter, varying in strength at the will of the speaker.

Mr. Edison's description of the circumstances under which he was led to the discovery of the motograph is interesting, demonstrating, as it does, the inventor's deeply investigating mind, and his inability to satisfy himself with superficial results. One day, while engaged on the fruitful problems connected with automatic telegraphy by means of chemically prepared paper, electrically discolored, he took up in his hand the metallic point, through which the current passes to the paper, retaining his loose grasp after the closing of the circuit and permitting the point to rest upon the paper. To his profound astonishment, he noticed that with the closing of the electric current, induced by the motion of the metallic point along the paper, the latter substance gradually lost its rough texture and assumed a soft and lubricated appearance. After hours of careful research, Mr. Edison was led to the belief that friction between the metallic point and the chemically prepared paper was greatly decreased by the passage of the electric

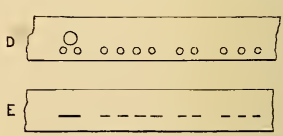


FIG. 7.—SAMPLE OF SENDING AND RECEIVING STRIP, MORSE CHARACTERS, EDISON AUTOMATIC SYSTEM.

current and that to the alternate opening and closing of the key was due the lubricated condition of the paper. Satisfied with these deductions, he abandoned the experiments for duties

of greater moment, expecting to take up the investigation at the same point and under the same conditions. To his amazement the results of the preceding day were no longer within his grasp, and for many months and years these phenomena eluded his investigations with an ingenuous persistency nothing short of diabolic. It was not until the summer of 1876 that the solution of the mystery presented itself and the underlying principles of the electro-motograph were practically applied to the production of a variety of important inventions, such as amongst others the speaking and musical telephone, and the signaling at distances by the use of bells, irrespective of electro-magnetism. In this latter case an upright clapper is utilized in place of the diaphragm already described, and this clapper, being released by the making and breaking of the current, strikes the bell.

The principle has been successfully used in lessening the friction incidental to machinery in rapid motion, and has been of peculiar value in accelerating the defective methods of oceanic cabling.

A special electro-motograph was constructed by Mr. Edison in connection with the transmission of oceanic messages, consisting of a very smooth disk of prepared chalk, revolved by clock work upon which a metal arm is made to rest, suspended in the middle by a torsion wire. To this arm is attached a graphite pointer or pencil, under which is a traveling strip of paper.

During the revolving of the disk and the cessation of the current, the pencil only marks a single straight line, but should the friction be released by a wave of electricity, the pointer instantly changes its position. By signs, formed according to these methods, a code of signals is easily constructed.

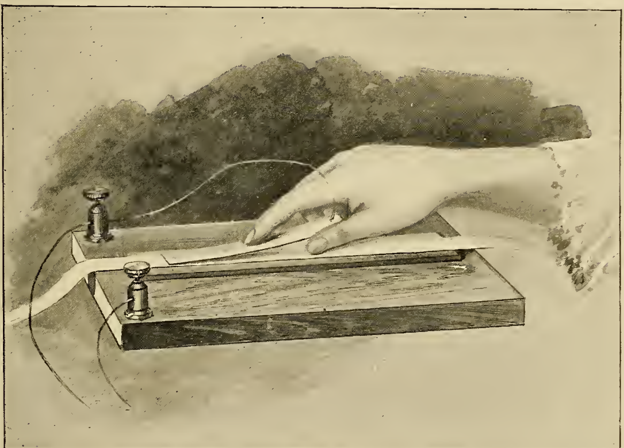


FIG. 8.—THE CHEMICALLY PREPARED PAPER AND METALLIC POINT. FIRST STAGE OF THE ELECTRO-MOTOGRAPH DISCOVERY.

In connection with the Carbon Telephone the electro-motograph has been of incalculable use in detecting the pulsations of the heart, however feeble, in one whom medical science has pronounced to be dead.

When the horrors of living entombment are taken into question, and the recognized difficulties of establishing the

presence of death, the value of this invention will be readily seen.

The following is the method employed: over the heart of the patient is placed a carbon receiver of peculiarly sensitive quality, attached by wires and a battery cell to an electro-motograph, constructed in such a fashion as to amplify many degrees the desired sounds. To the delicately responsive surface of the carbon, the pulses of the heart audibly respond, communicating a series of vibrations to the diaphragm of the electro-motograph. This method of sound amplification is immeasurably superior to that effected by the microphone, inasmuch as quantity is attained without injury to the inherent quality of the sound. There is nothing within the practical range of the microphone which may not be attained by the electro-motograph, with results infinitely more favorable to scientific research.

Simultaneous with this line of thought was the discovery of the carbon button, and the indefinite extension of powers concealed within its unpretentious limits. In 1873 Edison's mind was much occupied with the defects attendant upon the transmission of messages over long submarine cables, and while constructing some rheostats or instruments used for the regulation of resistance in a circuit, he brought into requisition certain powdered substances, such as carbon, plumbago, etc., immured in glass tubes, the variable action of which, under electric pressure, was sufficiently remarkable to engage his attention. It was found that carbon varied its resistance to the passage of electric currents according to the degree of pressure to which it was subjected. This extreme sensitiveness proved at first a source of great annoyance, and after many futile efforts Mr. Edison abandoned the idea as being unsuitable in connection with the nice regulation of resistance in electric circuits. It was not until 1877 that he again took up his disused discoveries, in connection with his ripened efforts in telephonic research, and applied them to a variety of valuable and successful inventions. From this prolific parent have descended the following scientific progeny: The transmitting telephone, the micro-tasimeter, or instrument for discovering inappreciable degrees of heat; the pressure relay, the carbon rheostat, the hygrometer, or instrument for detecting the slightest moisture; and the odorometer, or instrument for detecting the existence of gases, or odors, ranging from the most pungent to the most delicate.

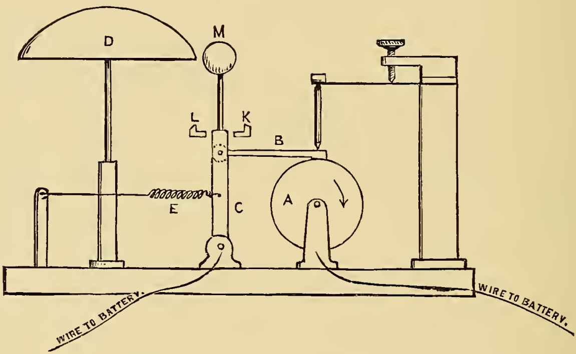


FIG. 9.—EDISON MOTOGRAPH FOR SIGNALING AT A DISTANCE.

Too much stress can hardly be laid upon the value and originality of the principles contained in the Electro-

Motograph and the Carbon Button. Of the former it has been authoritatively stated that were the electro-magnet undiscovered, the application of this method would amply suffice for the carrying out of all branches of telegraphy. "It is the most essential of all the means of giving motion," remarks Mr. Edison, "and a telegraphic relay has been made to do the work perfectly by one cell of battery through a resistance of twenty-five million ohms. The rapidity of action is so great that it will repeat signals sent automatically from one telegraphic circuit to another, at the rate of twelve thousand words a minute. Used as a telephone it will render audible, in a large room, conversation sent over a wire several hundred miles long, when the ordinary Bell receiver must be held close to the ear. This instrument will undoubtedly come into general commercial use as soon as the numerous patents have expired. During the controversy between competitive telegraphers several years ago, one of the companies owned what is called the Page Patent, which virtually controlled the use of a magnet acting as a relay, and the motograph being based on a new and original discovery entirely evaded the patents. One of the companies was therefore compelled to purchase the patent from me for the sum of $100,000. The application of this discovery to telephonic uses was brought about in the following manner:

"My agent," says Mr. Edison, "had formed a company in England to exploit the carbon transmitter, the same which is now used so extensively in telephony. The Bell Company also had a company in England and were infringing my transmitter at the same time that I was infringing their receiver. Bell's patent was afterward proved invalid, while my transmitter was sustained, and held the monopoly of the telephone in England for many years."

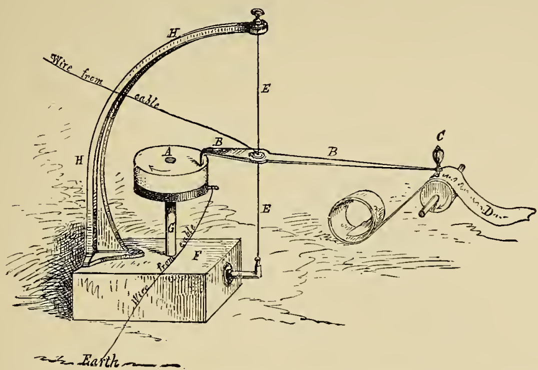


FIG. 10.—EDISON MOTOGRAPH, USED FOR ACCELERATING SPEED OF OCEAN CABLES.

A consolidation became imminent. Edison's agent telegraphed that they would have to resort to that expedient

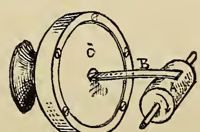


FIG. 11.—THE CARBON BUTTON.

on terms, which, as they assured only one-third to the inventor, did not meet with that gentleman's approval.

"I replied by telegraph," says Mr. Edison, "to hold back the negotiations

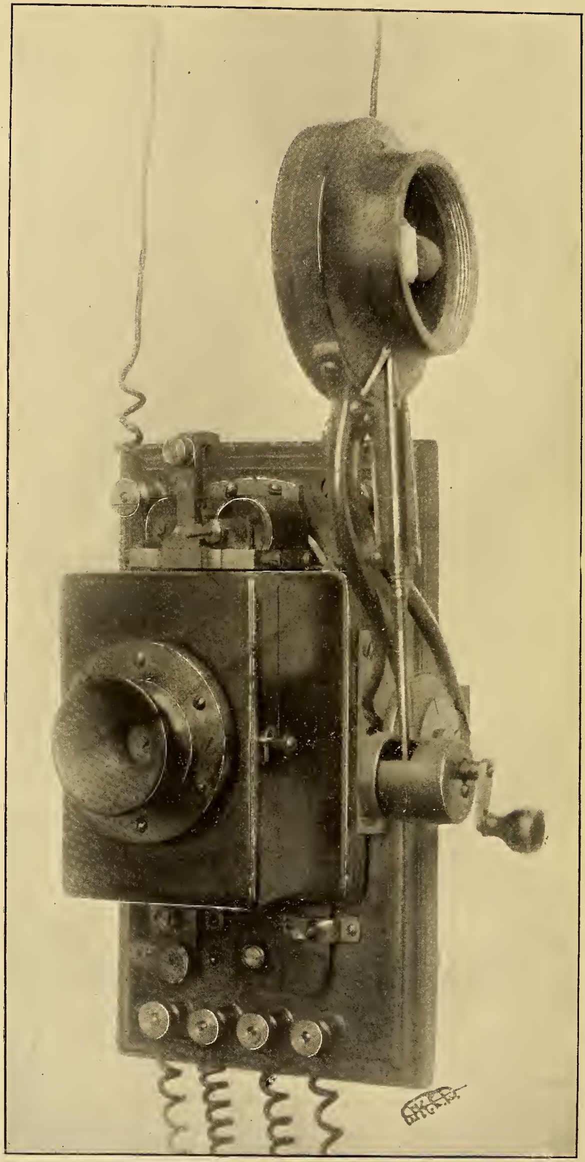


FIG. 12 —THE EDISON MOTOGRAPH RECEIVING AND TRANSMITTING TELEPHONE.

for three weeks, so as to give me time to invent a new receiver, independent of Bell. I then withdrew my whole force from the electric light, which I was then investigating, and put them on telephony." The practical outcome of this concentrated energy was the completion, in one week, of a satisfactory telephone, based upon the new discovery, and in sixteen days twenty instruments were constructed and on their way to England, under charge of two picked experts. The substitution of the new methods for the old took place in the newly established Exchange in London, a consolidation was effected, and Edison's stipulated terms of equal division were acceded to.

At the risk of somewhat anticipating the chronological sequence of Mr. Edison's inventions, we may state that the loud speaking telephone proved a signal success in England. It was found to the amazement of the public that by the use of a special instrument the reproduced voice could be made louder than that of the original speaker, notwithstanding the loss on the line. Insular prejudices melted before the manifold advantages of the new invention, and the new system was successfully grafted upon the social, political, and commercial workings of the day.

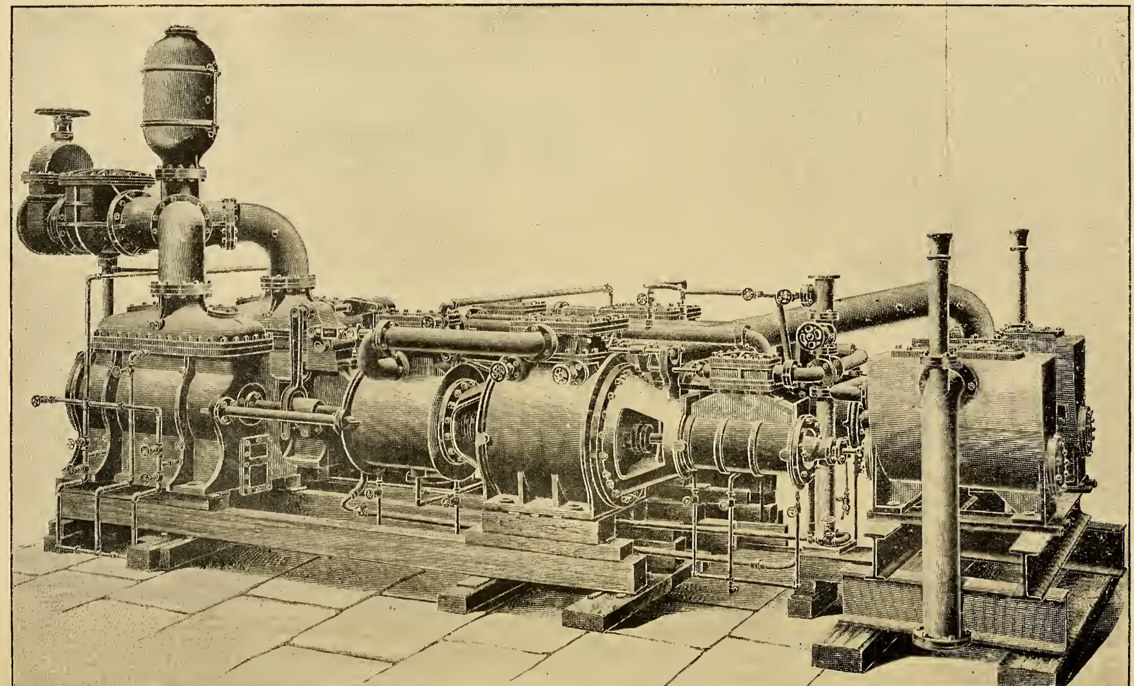
It will be seen that of the inventions belonging to the first six or seven years of Edison's comparatively untrammeled career, covering the period of his stay in New York and Newark, that is from 1869 to 1876, some were wholly and some were partially matured and clinched by patents. The large number, however, were merely rudimentary, containing germs of a perfection which were to be evolved in later years, and under improved facilities. Some brief description of these will be given in chronological order, and under their more matured conditions, but an exhaustive survey of Edison's inventions would constitute, in itself, a moderate sized library, and would be totally out of keeping with a work of the present general character. Any one who attempts the task of even wading through a simple catalogue of his inventions can enter intelligently into the description of the inventor supplied by the United States Patent Commissioner, "a young man who has kept the path to the Patent Office hot with his footsteps." If this were true of Edison at the comparatively immature age of twenty-four, what may not be claimed for him now, with twenty years of past scientific successes, and the promise of countless better things to come?

(*To be continued.*)

AN ENGINEER'S VALENTINE.

When a person knows so much
More than common folks and such,
Of all that's useful, wise and good,
How heathen first carved stone and wood,
When Tubal Cain first forgèd iron,
Who made the armor of King Priam,
The alchemic secrets can reveal,
Tell how to make the strongest steel,
How swords are made by Moslem Turk,
The Swiss lake-dwellers handiwork,
Whence King Solomon mined his gold,
How Hansa merchants bought and sold
The wondrous mediæval lore,
How ancients mined and melted ore,
Who first made each Yankee notion,
From ideas born across th' ocean,
The names of all the patentees,
Inventions first made by Chinese,
And by figures clear and fair,
Can surely make the circle square,
And in the plainest kind of speech,
Prove $\sqrt{2gh}$.
And can discourse on these at length,
With memory of such brutal strength
As fits a cyclopædia.
In fancy free, I'd speedier
Remain a maid to end of time,
Than have him for a valentine.

A. M. B.



PUMPING ENGINES FOR HYDRAULIC MINING IN NEW SOUTH WALES. CONSTRUCTED BY THE AUSTRAL-OTIS ENGINEERING CO., LIMITED, MELBOURNE, AUSTRALIA.

SOME NEW PUMPING MACHINERY.

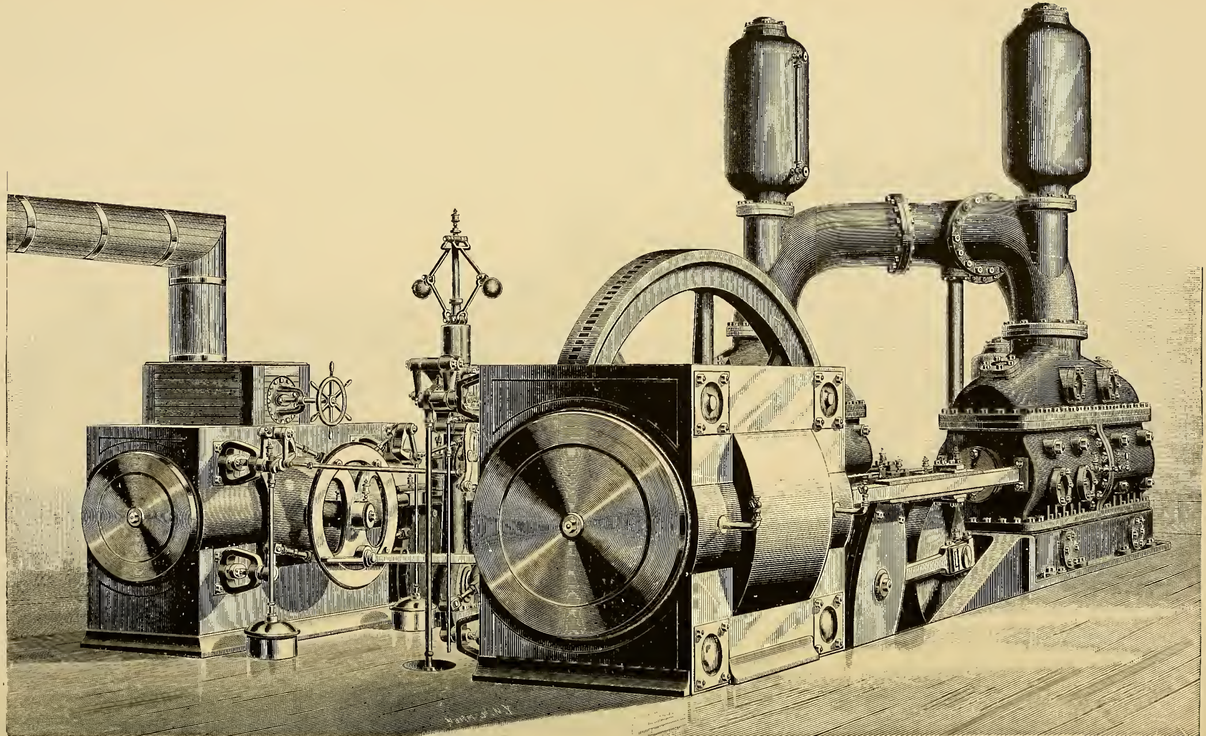
By Geo. L. Clark.

THE increasing demand for high duty pumping machinery capable of standing constant operation and economic consumption of steam, at the same time being what might be called reasonable in prices, brings to notice several compound pumping engines ; one of these is the pumping engine illustrated herewith, which has been built for the water supply of Managua, Nicaragua. There are two twelve-inch diameter high-pressure, two twenty-inch diameter low-pressure steam cylinders, and two twelve-inch diameter water cylinders, all twelve-inch stroke. The lever motion for working the valve gear is fitted with telescopic pieces, having long bearing surfaces, which are readily oiled from a lubricator provided at the top of each. This arrangement dispenses with the usual radius links and pin joints, thus reducing the number of wearing parts. The steam cylinders throughout are lagged with sheet steel, packed with slag wool, and secured by brass bands, making a very neat and efficient covering. Cushioning valves are fitted to each cylinder. The water cylinders are fitted with easily removable barrels, secured in place by set screws, and are provided with deep buckets and cup leathers. The water valves are of Evans' patent rotating disc type, with brass gratings and guards. The water from the delivery branch is passed through the tubes of a surface condenser. For convenience of space this latter is placed at right angles with the centre line of the main engine. The barrel of the condenser is of wrought-iron, double riveted in the longitudinal seam, and doors of the full diameter of the condenser are provided at either end for access to the tubes. The exhausts from the low-pressure cylinders are brought together by means of a forked piece, and led through a two-way valve, this latter being provided for the purpose of turning the exhaust either to the atmosphere or to the condenser, as desired.

The air pumps are on Messrs. Evans' Cornish principle, with Tonkin's patent steam cylinders, each steam cylinder being five-inch diameter, and each air pump barrel eight-inch diameter, all twelve-inch stroke. The air pump barrels are fitted with gun-metal liners. All valves are above the water-cylinder, and the capacity is so adjusted that the water level does not fall below the top of the pistons, consequently a very efficient air pump is the result. Either one of the air pumps could on emergency do the work. The engines are capable of delivering over 50,000 gallons of water per hour. They have to draw their water from a lake 1000 feet distant, through a twelve-inch diameter suction pipe, and deliver through 6000 feet of twelve-inch delivery pipe to the reservoir 180 feet above the pumps. The working steam pressure is ninety pounds per square inch.

One of the latest types of water-works engine in America is that which is illustrated on the pages following. It is a high duty, cross-compound automatic cut-off pumping engine, made by the Geo. F. Blake Manufacturing Company, of New York and Boston. In the construction of this engine will be found some novel features of unusual interest. We append also a test made by Mr. F. W. Dean, consulting engineer, Newton, Mass., for which city this pumping engine was built.

The engine is of the direct-acting, fly-wheel, cross-compound type, having one high pressure and one low pressure steam cylinder, with two double-acting inside plunger pumps. Both high and low pressure steam



CROSS-COMPOUND PUMPING ENGINE, DESIGNED AND CONSTRUCTED BY THE GEO. F. BLAKE MANUFACTURING CO., OF NEW YORK, FOR THE CITY OF NEWTON, MASS.

cylinders are provided with a Corliss automatic valve gear. The axis of each steam cylinder coincides with that of its corresponding pump cylinder. The fly-wheel is placed between the cylinders and is attached to the piston-rods through connecting rods, beams and links. The air and feed pumps

Diameter of the high pressure cylinder	21	inches
Diameter of the low pressure cylinder	42	"
Diameter of two pump plungers	13½	"
Diameter of all piston rods	4	"
Stroke of all pistons and plungers	40	"
Diameter of one single acting air pump	26	"
Stroke of same	12	"

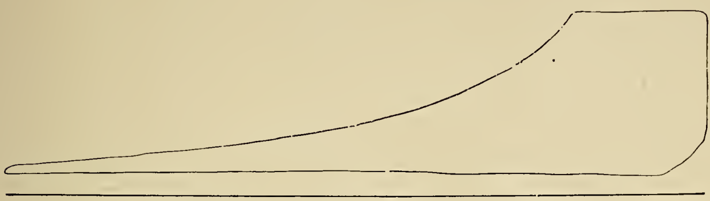


DIAGRAM FROM HIGH PRESSURE CYLINDER. CRANK END.

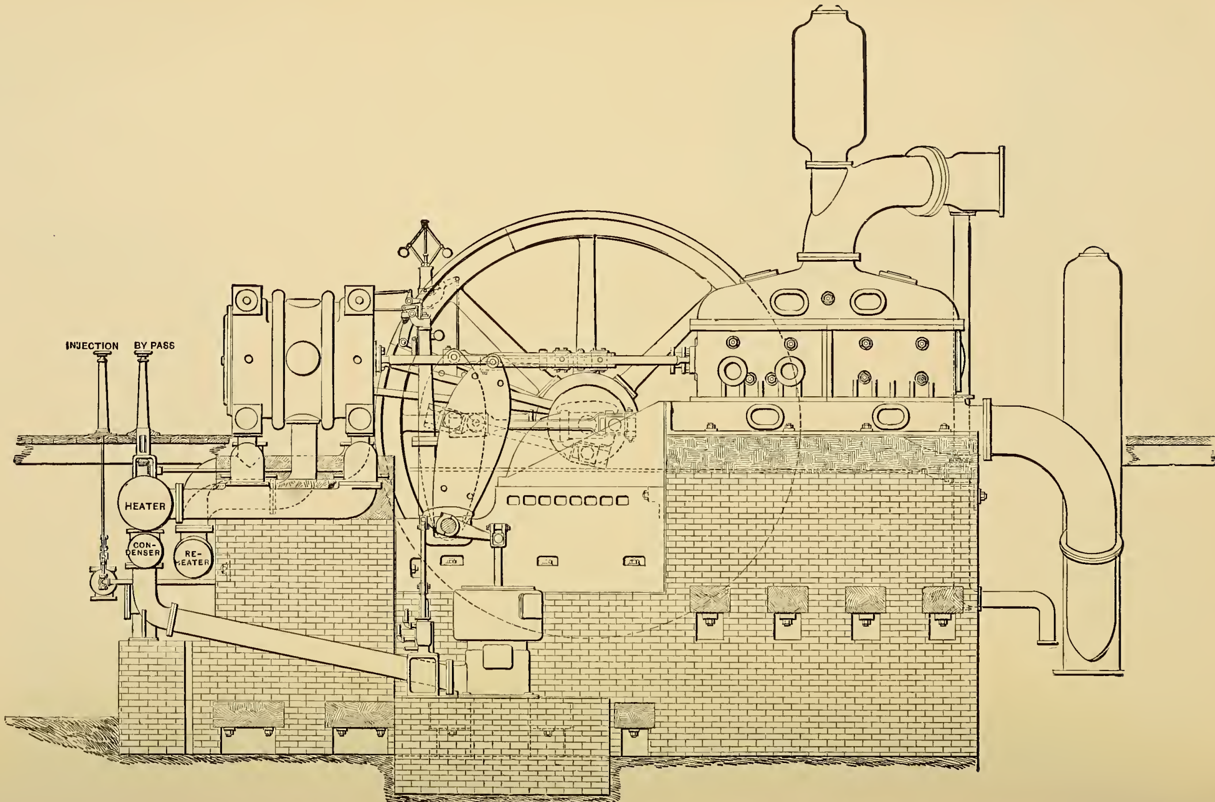
DIAGRAM FROM HIGH PRESSURE CYLINDER. BACK END.

are driven from the beam-shaft of the low pressure cylinder. The pump cylinders are provided with a great number of small valves, giving a very large area for the passage of water to and from the cylinders.

The dimensions of the engine are as follows:

Diameter of single acting plunger feed pump	4½	ins.
Stroke of same	6	"
Diameter of pump plunger for returning reheater drain to boiler	2	"
Stroke of same	6	"

The grate of the boiler was measured and found to be seven feet long and seven feet wide, less a longitudinal sep-



SIDE ELEVATION. CROSS-COMPOUND PUMPING ENGINE, DESIGNED AND CONSTRUCTED BY THE GEO. F. BLAKE MANUFACTURING CO., OF NEW YORK.

arating wall, seven feet long and thirteen and one-half inches wide. The steam at the boiler was assumed to be dry and saturated.

The results of tests made for the city of Newton by F. W. Dean, M. E., are as follows:

1. Duration of the test.... 24 hours.
2. Total number of revolutions................ 55326.

8. B. T. U. per horse-power of steam cylinders per minute.............. 253.
9. Horse-power of pump plungers.... .... 229.23

Water evaporated.

10. Per pound coal from temperature of feed and at boiler pressure........ 9.91 pounds.
11. Per pound of combustible from temp. of feed and at boiler pressure..... 10.69 "

DIAGRAM FROM LOW PRESSURE CYLINDER. CRANK END.

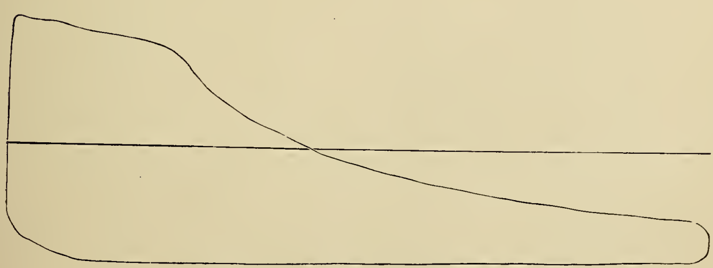
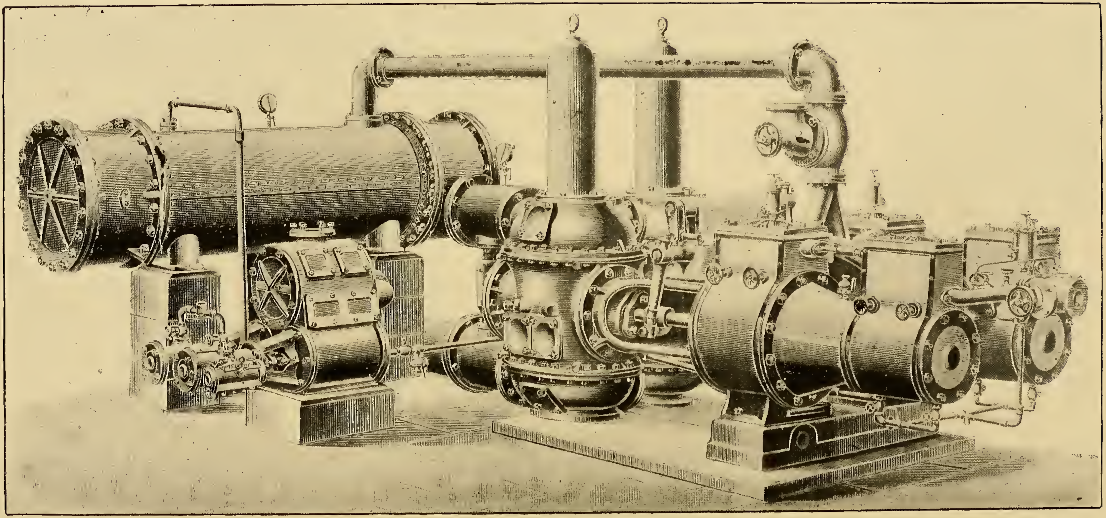


DIAGRAM FROM LOW PRESSURE CYLINDER. BACK END.

3. Average steam pressure at the boiler, by gauge 125.6 pounds.
4. Average steam pressure at the engine, by gauge 122.31 "
5. Pressure of the atmosphere................ 14.72 "
6. Effective resistance, per square inch, on pump plungers. .... 105.986 "
7. Steam per horse-power of steam cylinders per hour................. 13.97 "

12. Per pound of coal from and at 212° F.......... 11.20 pounds.
13. Per pound of combustible from and at 212° F.. 12.08 "

The annexed table shows the result of the analysis of the George's Creek Cumberland lump coal used. The calorific value, as determined by a Thompson calorimeter, was 13452 B. T. U., and, as shown from the



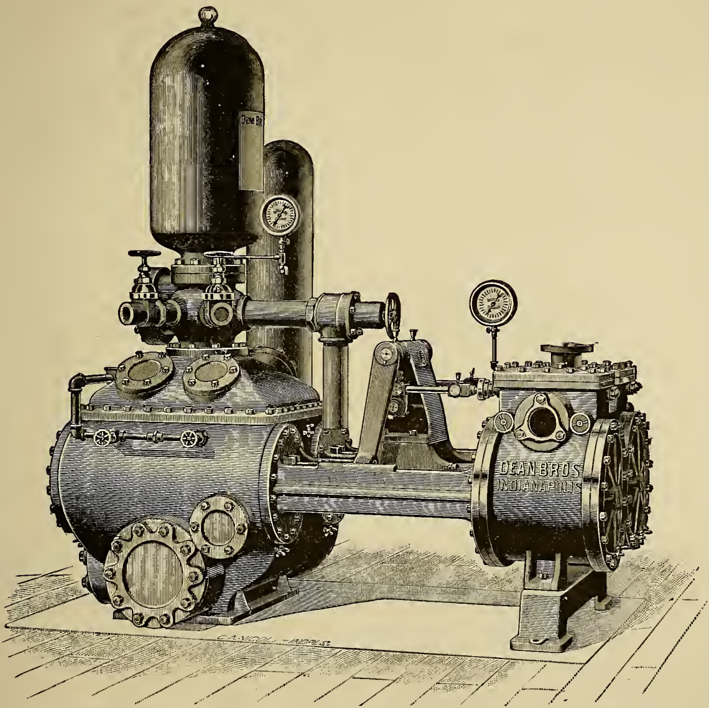
COMPOUND CONDENSING DUPLEX PUMPING ENGINE, BUILT BY JOSEPH EVANS & SONS, WOLVERHAMPTON, ENG., FOR THE WATER SUPPLY OF MANAGUA, NICARAGUA.

evaporation during the test, 10816.8 B. T. U.

Moisture	0.58	per cent.
Carbon	79.40	"
Hydrogen	5.11	"
Oxygen	3.80	"
Nitrogen	1.25	"
Ash	9.24	"
Volatile sulphur	0.62	"
Total	100.00	

Duties based upon the heat given to each pound of water fed to the boiler.

17. Per 1,000,000 B. T. U.	118,128,445	ft. pounds
18. Per 1100 × 965.8 B. T. U., Newton co-efficient	125,497,323	"
19. Per 1,000 pounds of water fed to the boiler	128,928,397	"
20. Per 100 pounds of coal burned	127,779,469	"

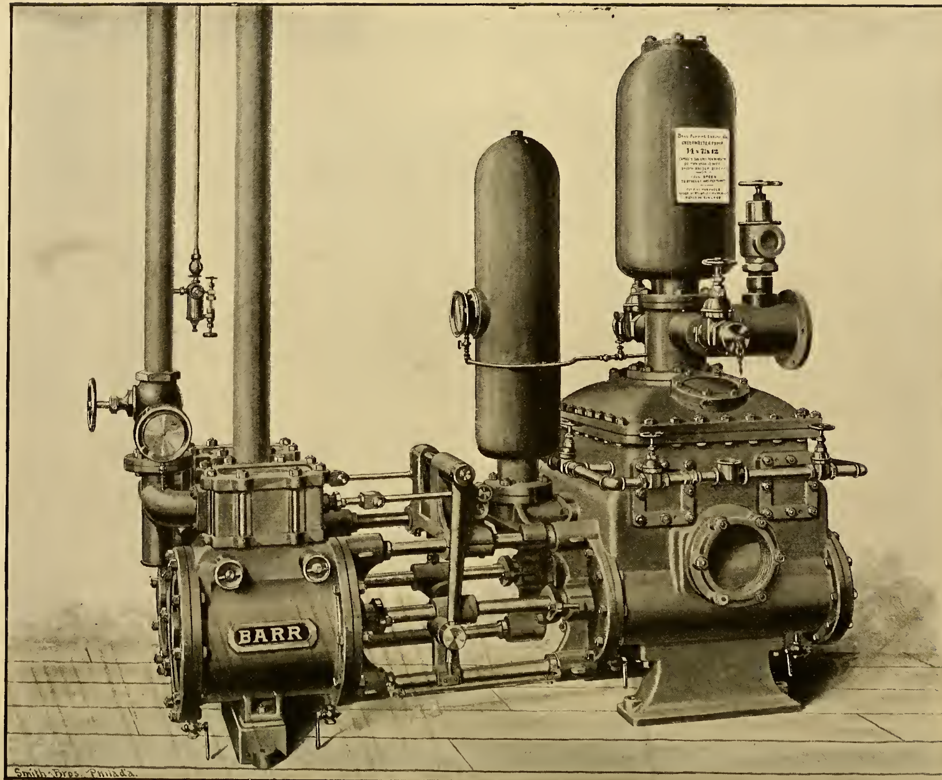


STEAM PUMP FOR FIRE DUTY, BUILT ACCORDING TO SPECIFICATIONS OF THE ASSOCIATED MUTUAL FIRE INSURANCE COMPANIES, BY DEAN BROS., INDIANAPOLIS, IND.

Duties based upon the heat received and rejected by the engine.

14. Per 1,000,000 B. T. U.	119,406,777	ft. pounds
15. Per 1100 × 965.8 B. T. U., Newton co-efficient	126,855,372	"
16. Per 100 pounds of coal burned	129,162,443	"

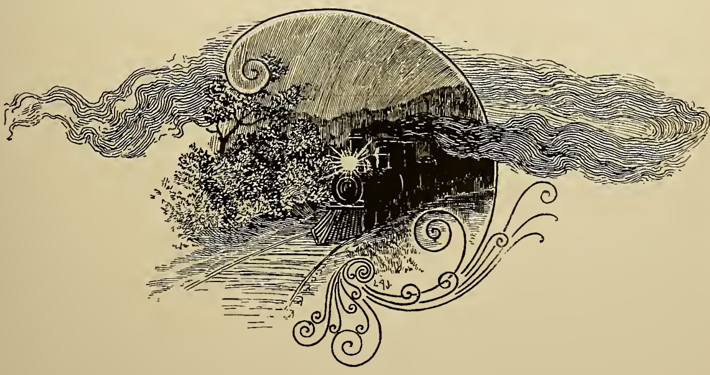
The pumping engine illustrated on page 298 was built for hydraulic mining in New South Wales. In this colony a rich alluvial gold field has been discovered on the banks of the Delegate river, near Bombala. The material consists of a bed of gravel thirty feet deep with an area of 200 acres, and which



STEAM PUMP FOR FIRE DUTY. BUILT ACCORDING TO SPECIFICATIONS OF THE ASSOCIATED MUTUAL FIRE INSURANCE COMPANIES, BY BARR PUMPING ENGINE CO., PHILADELPHIA, PA.

shows gold averaging about two shillings six pence per cubic yard, and is peculiarly suited to hydraulic mining, but no body of water was available within any moderate distance at a sufficient height to give an effective head for this purpose. Acting on the advice of their consulting engineer, Mr. H. C. Mais, M. I. C. E., the Delegate River Hydraulic Sluicing Company determined to create a head artificially by pumping into a reservoir constructed 150 feet above the mine and about a mile away from it. The order for the pumps was intrusted to the Austral-Otis Engineering Company, Limited, of Melbourne, who have built those shown on our engraving. These pumps are the largest yet built in Australia, and do much credit to the present standing of mechanical engineering in that colony. As will be seen they are of the duplex triple-expansion type. The cylinders are eleven and one-half inches, eighteen and three-quarter inches, and twenty-nine and one-half inches in diameter respectively, and pump plungers are thirteen and three-quarter inches in diameter, the stroke being twenty-one inches. The weight of each set is thirty-nine tons. They are designed to pump 4,500,000 gallons per day against a head of 300 feet. Steam at 120 pound pressure is supplied by four steel multitubular boilers, sixteen feet long by six feet six inches in diameter, weighing eleven tons each. The boilers are mounted in brickwork and have what is known as the "Otis" arrangement of stepped grates for economically burning wood fuel. The whole of the plant was constructed by the manufacturers in the short space of eleven weeks.

In a previous issue of this magazine there was printed a general description of the underwriter fire pumps, and the reasons advanced for special construction according to the specifications as laid out by John R. Freeman for the associated mutual fire insurance companies. A number of the leading makers of steam pumps are now building machines according to these specifications. Those brought out by the Barr Pumping Engine Company of Philadelphia, Pa., and Dean Bros., Indianapolis, Ind., are illustrated herewith.



HEAT MOVEMENT IN STEAM ENGINE CYLINDERS.*

By Prof. Kirsch, of Chemnitz.

THE theory of the steam engine was originally framed upon the assumption that the cylinder was impervious to heat. This opinion was based upon a study of the outside wall; but it came gradually to be recognized that the various phenomena connected with the loss of heat took place on the inner surfaces of the cylinder in contact with the steam. Hirn and his coadjutors were the first to perceive the importance of this question, and to approach it experimentally. Grashof, Zenner, Dwelshauvers-Dery, Schmidt, and others, have worked out the subject on the lines laid down by the Alsatian school, and have brought what is known as the "calorimetric study" of the steam engine to a high degree of perfection; but no one has yet been able to determine with certainty the movements of heat in cylinder walls.

To obtain a correct idea of the depth to which the fluctuations of temperature penetrate into the wall, the author is of opinion that the layer marking the limit reached will probably be found further removed from the innermost surface of the cylinder the better the conductivity of the material used; while the shorter the time occupied per revolution, or the greater the number of revolutions per minute, the nearer this fluctuating layer will be to the surface. If it be assumed that the temperature at this depth fluctuates only about a thousandth part as much as at the innermost surface next the steam, this depth, the author says, will be 26 millimetres (1.024in.) with twenty-five revolutions, and 13 millimetres (0.512in.) with one hundred revolutions per minute. These figures show that in an engine running at ordinary speeds, and with ordinary thicknesses of wall, the fluctuation of temperature inside the cylinder practically ceases before the heat is passed through the wall, and the thickness of the wall does not affect the time occupied by each fluctuation. It is possible to calculate the mean temperature of any part of the inner surface from the permanent temperature of the wall beyond the limit of fluctuation.

After some observations on the method to be followed in plotting out a temperature curve to represent the movement of heat in the thickness of the wall, the author proceeds to consider what is the amount of heat passing through the cylinder from a given point in its inner surface. This he represents graphically by a curve. Without giving the proofs in detail, it may be safely conceded that every fluctuation of temperature at the innermost surface must give rise to a corresponding heat movement throughout the thickness of the wall. If the inner surface temperature is raised by contact with the steam, the heat thus received will pass in a stream outwards from the inner surface and increase the heat stored up in the walls. But if the temperature at the inner surface falls, the direction of the stream of heat will be arrested and reversed, and the heat in the wall decrease. This counter movement of the heat current, however, will not be quite instantaneous, because when the temperature curve attains its zenith, the innermost surface, although its temperature may be slightly diminished, will still be hotter than the anterior layers, and the return current will not set in until the interior layers are hotter than the surface. Exactly the same process is repeated when the lowest point of the temperature curve is reached. The curve representing the heat stored up in the wall will stand in

*From Foreign Abstracts, Institute Civil Engineers, London.

the same relation to the temperature curve of the innermost surface as the curve of the extreme limit of fluctuation in the wall.

By the use of tables, algebraic forms, and diagrams, the author reduces the inquiry into the movement of heat in the interior of the cylinder to the simpler question, What is the temperature at any given moment at the innermost surface? If this temperature were known for each position of the crank, and for each part of the surface in contact with the steam, only the coefficients for heat conduction would remain undetermined, and these can be obtained by comparatively simple experiments. The vital point is the ignorance, even at the present time, of the relation between the temperature of the wall surface at any given moment, and of the steam in contact with it. This can only be ascertained by direct experiments, and, to make these decisive, they should be undertaken on a wide scale. The author indicates the direction in which they ought to be carried out.

Apart from the influence of certain minor circumstances, such as the smoothness, greasiness, etc., of the metal touched by the steam, it is evident that two diametrically opposite effects will be produced, according to whether the steam is hotter or colder than the walls. If the steam be hotter it will produce condensation on the colder wall and heat the innermost surface almost instantaneously to its own temperature. The water thus formed will either adhere as dew to the surface, or be carried off by the steam, or wiped off by the piston, or, if present in any large quantity, it will run down in drops. In the contrary case, where the wall is hotter than the steam, an equilibrium of temperature will be rapidly established as long as the wall is wet, and therefore in a condition to part with a considerable amount of heat by re-evaporation. But as soon as it has become dry, heat can only with difficulty be given off. In short, the author thinks it safe to assume that the innermost surface of the wall cannot anywhere, or for any length of time, be much colder, but may be temporarily or permanently hotter than the steam in contact with it.

Where superheated steam is not used, the indicator diagram will show the fluctuations of temperature in the steam. The pressures of the steam for each position of the crank thus determined, the corresponding temperatures can be obtained from the steam tables. The temperature curves of the steam at the top and bottom of the piston should be blotted out, and the position of the crank agreeing with the temperature of the steam at any given part of the surface will be seen. The author also proves by the graphic method he has adopted that the fluctuations of temperature in the middle of the cylinder are only half as great and succeed each other twice as quickly as at the ends ; therefore the exchange of heat in the cylinder covers is much greater than at the centre of the cylinder.

If the wall were always wet the fluctuations of temperature at the surface would be almost exactly the same as those of the steam in contact with it. But the dry wall cannot part with its heat so quickly as the wet, and at the moment when the wall becomes dry the stream of heat coming from the interior is stored up at the surface, and raises its temperature above that of the steam until, as the temperatures of both diminish, the heat is given off in radiation and conduction. This process cannot be shown by measurement, but from the moment the wall becomes dry the stream of heat is, so to speak, interrupted, the heat curve falls to a straight line and the fluctuations of temperature can be retrospectively determined from it.

The author thinks that only the mean temperature of the wall can be known from observation. By comparing this with the mean temperature of the steam at a given point he proposes to ascertain whether, and for how long, the wall at that particular spot is dry. Few experiments on this special subject are on record. The best are those made by Mr. B. Donkin, jun., with his revealer, and reported by Professor

Dwelshauvers-Dery, in the "Bulletin de la Société Industrielle de Mulhouse," and also Mr. Donkin's method of taking the temperature of cylinders. These experiments appear to confirm the author's opinions; but, however excellent, they do not afford a sufficient basis from whence to deduce the movements of heat, which cannot be known until the following questions are settled:

1. What is the behavior of the condensed water running down the cylinder walls under different circumstances?

2. How far can the data furnished by the indicator be really relied on to give the pressures and temperatures of steam in the interior of the cylinder?

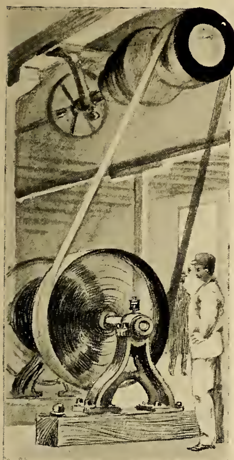
To determine the first question the author thinks the following experiments ought to be undertaken: A steam engine with a surface condenser, to give the weight of steam used, should be provided with a series of plates to fix on to both sides of the piston and one on to each cover. These plates may be varied to suit different circumstances, according to the material used and the extent of surface; but the clearance spaces of the engine must always be the same and only the extent of these inner surfaces should change. The plates should have deep rectangular teeth or ribs, as shown in the author's drawing, giving as large a superficial area as possible, and be fixed in the cylinder first with the teeth vertical, that the water condensed may run off, and next parallel to the piston, to catch the water as it is formed in the teeth. To compare the results of these two different experiments the consumption of feed water in each case should be measured, and all the other conditions being the same, the effect, if any, of the water running down will be determined. If the material of the plates were varied, and teeth made, alternately used, of bismuth and of copper, the experiments would also serve to show whether these metals have the same conductivity in the interior of the cylinder as in the laboratory. To affect the rate of consumption of steam as much as possible, these surfaces should be more prominent than the rest of the cylinder. The trials would also probably indicate the best method of reducing the losses by cooling of the cylinder covers and piston.

To determine if the mean steam pressures reckoned from the indicator diagrams agree with the actual pressures at any given zone in the cylinder, the author proposes to bore a small hole in the wall, and fix a copper tube in it, with a manometer at the end of the tube to register the constantly fluctuating pressure.

Touching lastly, and very briefly, upon the important question of heating the cylinder, the author says that the first object is to diminish the heat given up by the walls to the exhaust steam. At first sight it seems as though the hotter the wall the more heat must be given off; but this is not the case. Heat being added from without, the equilibrium between the heat set free by condensation, and that taken up by re-evaporation is disturbed, because at every stroke a fraction of heat, however small, is left in the wall, its mean temperature rises, while condensation is continually diminishing. But this condition cannot be established until the mean temperature of the wall has been raised so much above that of the steam that the wall can pass on to the steam the excess of heat it has received, even after the condensed deposit has disappeared. Probably there will be no condensation, except at the moment of maximum temperature—that is, during admission and the beginning of expansion, and the principal part of the heat given up to the wall will be restored at a time when it can still do useful work on the piston.

VARIABLE SPEED POWER TRANSMISSION.*

By H. C. Spaulding, Mem. A. S. M. E.



OF the mechanical devices, if such an estimate could be made with any approach to exactness, it would be most interesting to know how many pairs of step pulleys are to-day in operation in the United States alone. Surely there are few mechanical contrivances more generally accepted and incorporated into every class of machinery for affording a simple and ready means of changing the speed either of the entire driven mechanism, or of one or more parts of it, independently of others. Yet their inherent defects are so well known as to call for hardly more than bare mention, in order that they may be borne in mind while considering the device herewith described. Inability to produce speeds other than those predetermined by the ratios of corresponding steps; the limited number of such speeds except as obtained by large and unwieldy cones with an excessive number of radii, at a corresponding expense in stock and finishing cost; inconvenience of shipping belts except as applied to light work and without stopping the machine, or at least depriving it of driving power while the change is being made; enforced parallelism of driving and driven shafts;—all are considerations so thoroughly appreciated by practical engineers and designers as to call for no extended comment. The demand for something which should offer the same advantages with fewer attendant drawbacks, has been partially met by a number of devices which have become more or less well known, in connection with various classes of machinery.

In spinning apparatus, speeders and fly-frames allow the use of continuous-element cones, the shafts being conveniently placed near together and parallel, while a continuous and gradual change of speed is obtained by slowly and automatically shifting the belt from one end of the cones to the other. Were the required range of speed greater, however, or the change more rapid, the device would evidently not produce such satisfactory results.

In woodworking machinery the use of a wheel so arranged that it may traverse a driving disk, its edge thus attaining a speed corresponding to that of the disk at varying distances from its centre, has been tried with more or less success, but the frictional contact (theoretically a line only) is so slight that saw-dust or dirt of any kind, on wheel or disk, is liable to interfere with uniform action, while the axis pressure of both parts must be excessive, and the driven shaft varies its position with every change of speed, necessitating an extra link in the mechanical transmission, with a consequent friction loss.

The Evans friction cone has recently been applied to a number of problems of this character, but is open to the objections inherent in all continuous cones, while the shafts must be close together, and expert opinions differ as to the durability of the belting used,

* Paper read before American Society of Mechanical Engineers.

owing to the peculiar and rapidly recurring stresses to which it is subjected when in operation.

Without dwelling upon other devices for obtaining the desired results, we come to a type of apparatus which seems to the writer to overcome most

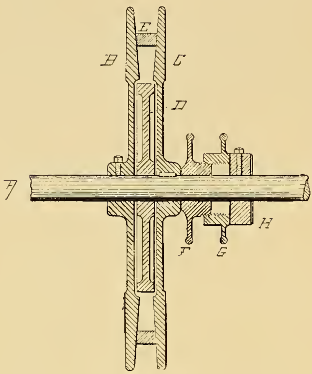


FIG. 1.

of the difficulties noted, in a simple and effective manner, the invention of Mr. E. F. Gordon, mechanical engineer of the John A. White Company, of Dover, N. H. In the opinion of those most interested in its development, it is worthy of more extensive trial and investigation than has been or can in the immediate future, be given it in the line of machinery to which it is now being applied, and in presenting it at this time it is hoped that its possibilities and limitations will thereby be more clearly brought out by actual demonstration.

Simply stated, the device consists of a deeply grooved pulley, split by a plane perpendicular to its axis, and dividing it symmetrically, with means for varying the distance of the two parts one from the other.

Given a belt adapted for the purpose, it will, in running on such a pulley, lie nearer the centre as the two parts are more widely separated, and recede as they are brought nearer together. Such a pulley may be used on either the driving or driven shaft, or both, and it is evident that the shafts may be at any practical distance apart, also that the greater the pull on the belt, the greater its hug and consequent freedom from slip. In some cases it is desirable to place a loose pulley between the two parts referred to, making a compact arrangement for starting, stopping and varying speed, in the space ordinarily occupied by a single pulley of the usual style.

Fig. 1 shows such an adaptation of the device, with one of the many available arrangements for varying the working radius of the pulley. In the illustration, *A* is the shaft, *BC* the two halves of the pulley, *D* the idler, *E* the belt, *FG* hand wheels, *H* a collar fast on the shaft. By the action of the belt, *B* and *C* tend to separate from each other, and since *B* is fast on the shaft, *AC*, which is splined on the shaft, and hence must turn with it, although free to move along, is forced against *F*. The hand wheels, *F* and *G*, are free to turn on the shaft, but may be held at rest whenever desired. The hub of

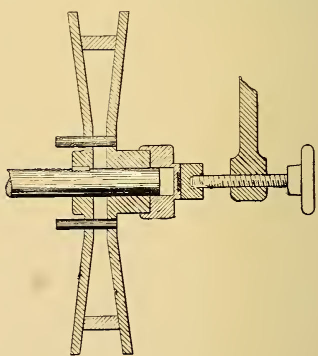


FIG. 2.

one carries a male screw, and the other a female, so that by altering the position of one on the other, they increase or decrease the distance between the collar, *H*, and the half of the pulley, *C*, thereby allowing *C* to recede to a greater or less distance from *B*, and de-

termining the position of the belt, *E*, and its consequent speed relative to that of the shaft, *A*. It will be evident that in this construction, when used as a driving shaft, the belt speed will become less and less as *F* is screwed into *C*, until *C* has so far receded from *B* as to allow the belt to drop on to the idler, *P*, when the driven mechanism will come to a standstill, to be gradually started again by the adjustment of *F* and *G*.

Fig. 2 shows a still simpler form, applicable when the pulley is located on the end of a shaft. In this case the loose pulley is omitted, it being assumed that only a speed adjustment is necessary, one part of the pulley being fast on the shaft, the other free, but loosely pinned to the first so as to rotate with it, the working radius being determined by the adjustment of a hand screw.

The belt may be either round or nearly square in section, though for the most of the experiments so far made a narrow double ply leather belt has been used, with the edge beveled to correspond with the angle of the pulley's face.

The construction shown in Fig. 2 has recently been applied to the feeding rolls of a forty-eight inch band resawing machine in a way which illustrates its simplicity and adaptation to this class of work.

Fig. 3 shows the arrangement of parts, *A* being the split pulley, its shaft being driven by a link belt from a continuation of the lower band wheel shaft and supported by an arm, *B*, swinging from this as a centre. The belt, *C*, drives the pulleys, *DD*, on horizontal shafts worm-geared to the axes of the feed rolls, the swing of the arm, *B*, compensating for the varying length of the belt, *C*, owing to changes either in position of the feed rolls, *E*, with reference to the saw, or in the working radius of *A*, the latter being determined by the position of a hand screw.

The diameter of the split pulley is twelves inches, the minimum working radius three inches, giving a linear speed to the surface of the feed rolls of from ten to thirty feet per minute. A double ply belt one inch wide is used, and its power is such that if the stock be held firm, the slip occurs between it and the feed rolls (four in number, all geared, eighteen inches long, three inches diameter), and not at the belt, as in the case of the usual style cone

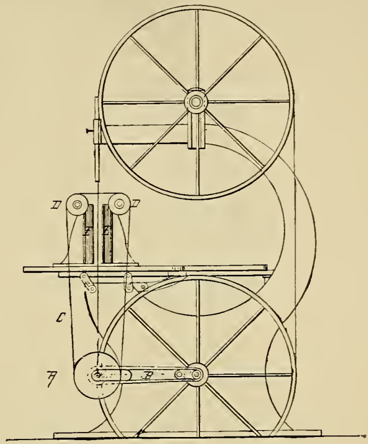
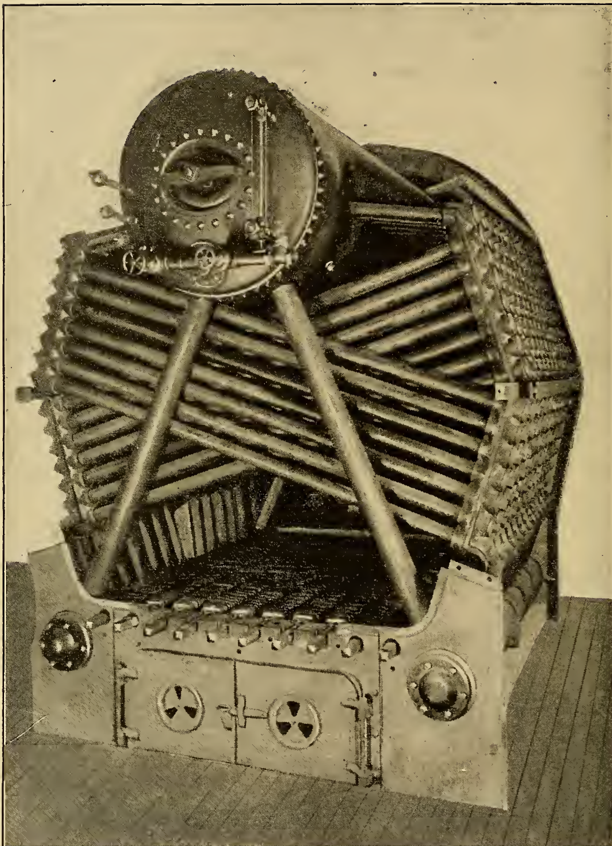


FIG. 3.

pulley formerly used with a machine of the same capacity.

No dynamometric tests have yet been made, but a pulley six feet in diameter is now nearly ready for careful investigation as to efficiency under widely varying loads and speeds. Should the results be satisfactory, the simplicity, compactness, reliability, and cheapness of the device would apparently warrant its extensive use where a variable speed is desired.



A NEW SECTIONAL WATER-TUBE BOILER.

A NEW SECTIONAL WATER-TUBE BOILER.

SECTIONAL boilers have grown so rapidly in favor during the last ten years that they may be regarded as a permanent type, and one which is likely to replace to a great extent the older forms of boilers. The Worthington sectional water-tube boiler illustrated herewith is the latest of the class to be put in the market. In the elementary details, such as four-inch inclined tubes expanded into headers, and a large horizontal water and steam drum, it does not differ from the older and well-known forms of water-tube boiler, but in the method of grouping of these details, and the resulting external form and appearance, it is quite novel.

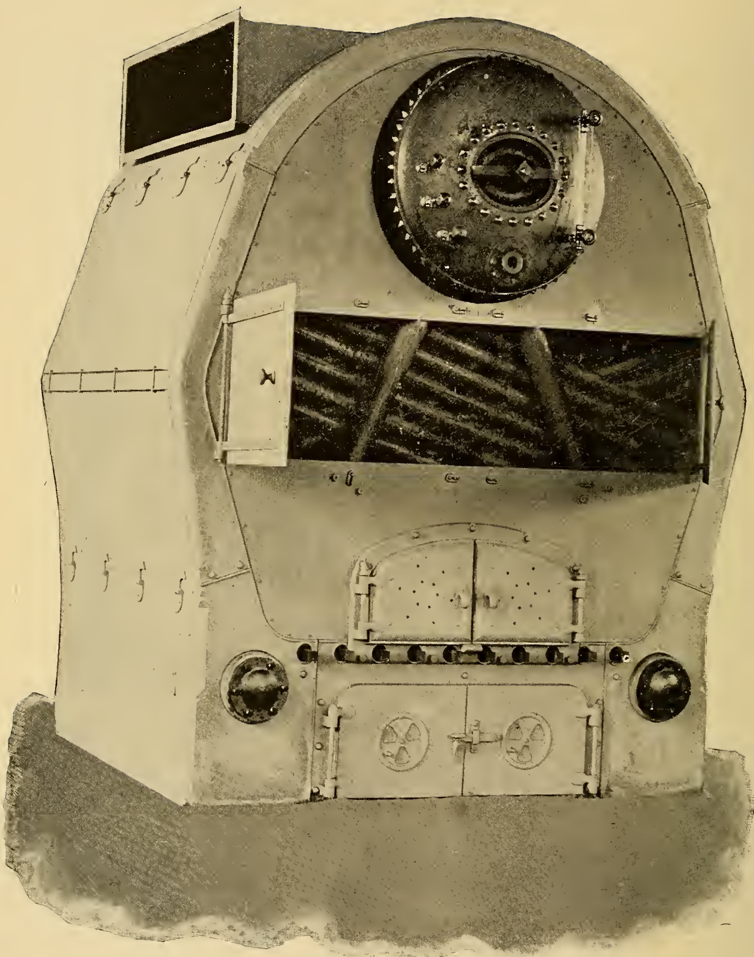
As shown in the engravings, the tubes are all straight, and are arranged in transversely-inclined series of several tubes per section.

The heating surfaces and water-ways are so arranged that the movement of the water contained in the boiler is constant and rapid. Its course is : from the steam and water drum located above the tubes, into which water is fed, it descends the water legs, four in number, placed outside the furnace, to the water and mud drums, at the base ; thence it passes via the tube connections, into the lower series of headers ; thence through the tubes, over the fire, into the upper series of headers ; thence via the tube connections into the steam and water drum again (from whence it started). It would seem that the proportion and combination of parts throughout the boiler is such, that expansion and contraction, due to changing temperatures, can occur without straining or disturbing the position of any part or system of parts.

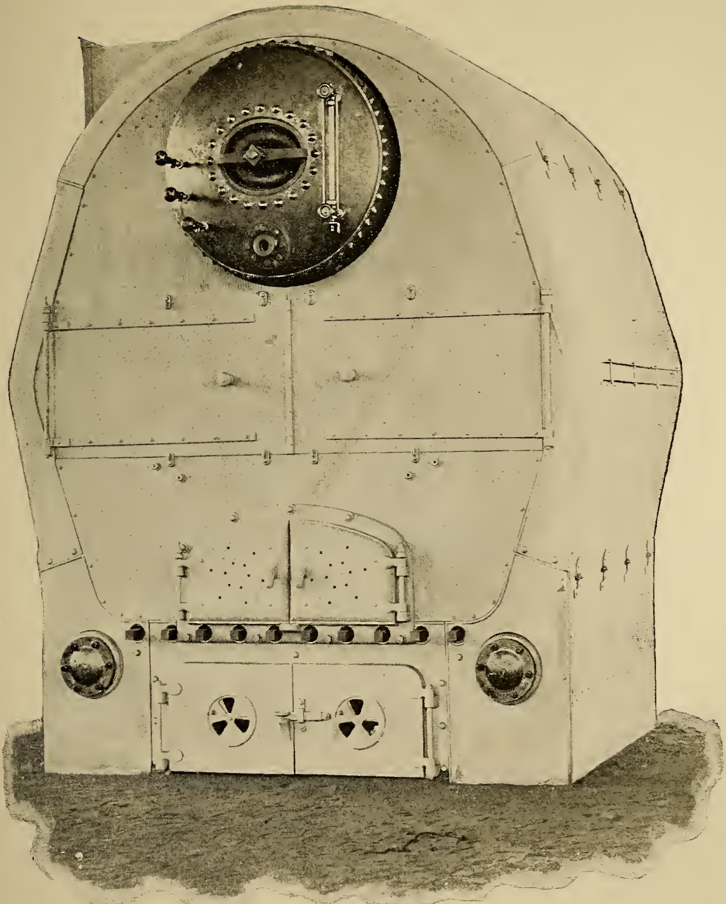
The headers are placed closely together side by side, forming complete side walls to the furnace, and affording a limited amount of effective heating surface. Opposite each end of each tube a hand hole, of proper size to admit a tube, or a tube-expander, is provided in the header, and fitted with a faced and ground cap, held to place with a crossbar and bolt. Each end of each mud drum is provided with a removable cap, accessible from the outside. No screwed joints are used in the boiler. The furnace is lined with fire brick. The only other brickwork required to erect a stationary boiler consists of two foundation walls of proper depth, rising above floor level about twelve inches. The external casing of the boiler is made of heavy sheet iron, lined with non-conducting material, and bolted to a wrought iron angle or channel bar frame.

Besides possessing the advantages of all the best forms of water-tube boilers, the system of cross-tubes employed in this boiler results in the concentration of heating surface, yet it does not contract the area of grate. The capacity of the boiler in horse-power per cubic foot of space occupied is claimed by the makers to be greater than is afforded by any other boiler now known to the market—"pipe" boilers excepted.

By reason of its sectional character, it can be delivered in places ordinarily inaccessible to any other desirable boiler. A boiler of 200 horse-power can be passed through a doorway, window, or sidewalk opening, four feet square. A boiler of 100 horse-power occupies a floor space seven and a half feet square, and is less than ten feet high. The boiler is built by the New York Safety Steam Power Company, New York city.



NEW WATER-TUBE BOILER. [SEE PAGE 315.]



NEW WATER-TUBE BOILER. [SEE PAGE 315.]

THE VALUE OF INDICATORS.

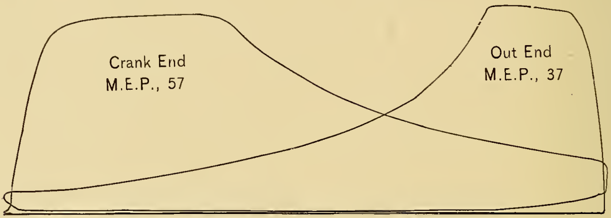
By Richard Thompson.

THE steam-engine indicator is fast becoming a prominent factor in the equipment of steam plants—not merely in the hands of those making a business of "indicating" and testing engines, but with the average engineer or manufacturer who wants to keep up with the times, and knows just what he is doing.

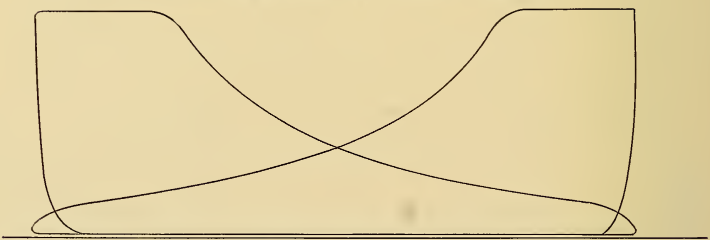
Many manufacturers and engineers, and even engine builders, consider the indicator a mere toy, or a dangerous tool, for which they have no use; but their mistake is easily shown. Some engineers claim to be able to set valves as correctly without the indicator as with it, and in some instances they may happen to get the adjustment nearly correct; but in most cases such "blind" setting is defective and inaccurate.

Every one who has made a success of steam engineering from the theoretical and practical sides, admits that the indicator is the only instrument by which the action of steam in the motive cylinder may be made plain, adjustments correctly made, and the results properly known.

Some time ago the writer came across some cases of extremely poor valve-setting by a man from the shop



NO. 1.—CYLINDER, 26 X 42. REVOLUTIONS, 71. SCALE, 60.



NO. 2.—CYLINDER, 16 X 42. SCALE, 60. M. E. P., 45. I. H. P., 136.5.

of a prominent engine-builder. In one instance it was on account of an increased consumption of coal that the superintendent of the mill decided to have the engine indicated, in order to see if the trouble might be accounted for and remedied—which was easily done.

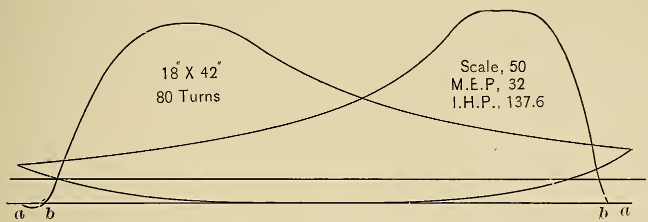
The three sets of two cards each here shown were taken from three different

engines in a New England town, not over five miles apart, with the Bachelder adjustable spring indicator, made by the Thompson & Bushnell Co.

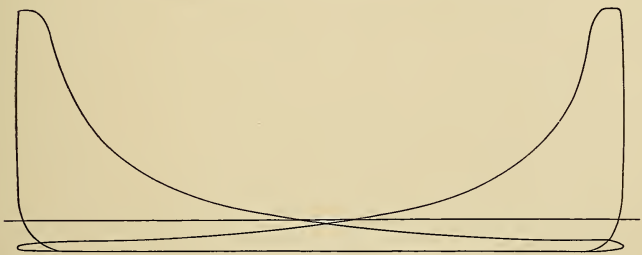
Card No. 1 is from a Corliss engine, 16 by 42, making 71 revolutions per minute, and run in connection with a water-wheel, and pounding badly. As will be seen, not only is the admission slow on both ends, but the cut-off is much later on the head end than on the crank end, so that while there is a mean effective pressure of 57 pounds on the head end there is only 37 on the crank end. There is no cushion at all, which accounts in some measure for the pounding. All this is in spite of the fact that a short time previous to the taking of the cards the cylinder had been re-bored, the valves set and all pronounced in first-class order. After advancing the eccentric 2⅜ inches, card No. 2 was taken, and this shows quite a different state of affairs—one which was highly satisfactory. There is slight compression just up to about the initial pressure; the cut-off is square on both ends and sharp on each.

Card No. 3 is even worse than No. 1. It is from an 18 by 42 Corliss engine, run condensing and at 80 turns per minute. Things are about as bad as they could be. Work on the two ends is not alike and is bad on both; the steam draggles in late, and the valve closes almost as soon as it has properly opened, and instead of there being fairly low terminal pressure and the back pressure being cushioned up by exhaust closure towards the end of the back stroke, the exhaust remains open and the effect of part of the stroke is lost, as will be seen by the horizontal line from *a* to *b* at each end. After adjusting by means of the indicator, card No. 4 was taken, showing work done clear out to the end of the back stroke, admission clear and sharp, cut-off practically the same on both ends, and expansion almost down to the back-pressure line.

About a month before taking these cards the owner of the engine (not



NO. 3.—CYLINDER 18 X 42. REVOLUTIONS, 80. SCALE, 50.



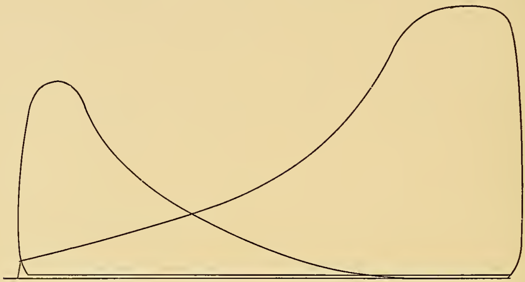
NO. 4.—CYLINDER 18 X 42. REVOLUTIONS, 80. SCALE, 50. M. E. P., 17. I. H. P., 73.1.

being satisfied with its working) sent to the builder for a man to come and put it in proper working order. While this man was "adjusting" the valves, he was asked if he did not use an indicator for such work, and he replied that he did not believe in them, as he could set the valves better without them. While this latter part may be true it is equally true that the valves could have been set better by any one with the instrument than by him without it—in fact the condition could not well have been worse. The engine having been pronounced by him "all right" and found to be far from right, the indicator was resorted to, and the result of using it in valve-adjusting is apparent. The changes were made during the noon hour, and without causing any delay or stopping.

In card No. 5 we have the record of the working of an 18 by 42 Corliss engine at 65 revolutions. The crank end was doing double as much as the out end—that is, two-thirds of the entire work of the engine; the valves opened late and there was no compression.

The indicator having been applied, it did not take long to produce cards such as are shown in Fig. 6, which are about as good as any one would call for.

Loss of steam (to say nothing of the wear and tear of the engine and the irregular running necessarily resulting) incurred by running an engine in such condition as is pointed out by cards 1, 3 or 5, must present itself to any one familiar with indicator diagrams. While such poor valve-setting as is shown by these odd-numbered cards is seldom seen, it is very rare that the valves are found properly adjusted unless an indicator has beeen employed.



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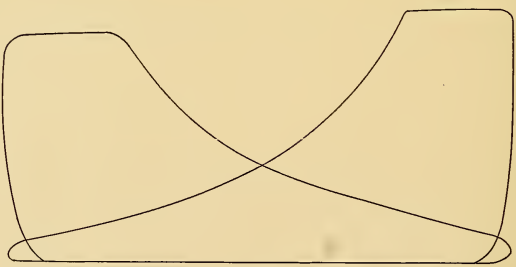

NO. 6.—CYLINDER, 18 X 42. REVOLUTIONS, 64. SCALE, 40.

J. B. ATKINSON,

President of the Mining Institute of Scotland.

CASSIER'S MAGAZINE.

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ELECTRICITY AND OUR COAST DEFENSES.

First Paper.

By Charles L. Atwell.

SOME of the devices used for the destruction of ships are not torpedoes, but that term has been popularly applied to all the numerous contrivances which have, from time to time, been devised for producing submarine explosions calculated to act destructively against ships in their immediate vicinity. This term is used whether the torpedoes are stationary, the charge being ignited automatically, or by the judgment of an operator at a distant station when a vessel passes within range of their sphere of action; or whether in a movable form, often auto-mobile in action, they are launched or controlled from warships or swift torpedo-boats. Keeping in view the peculiar conditions and qualifications requisite to the successful use of the weapon, the writer has adopted the broad and natural classification of torpedoes as *offensive* or *defensive*.

The development of the first, the offensive class, which is operated from shipboard and designed for the active attack of vessels, has been assigned to the navy, as success in manœuvring implies technical knowledge peculiar to the profession of a sailor. The functions and mechanical features of torpedo boats, "catchers," and "cruisers," auto-mobile torpedoes of many types, submarine boats, and Ericsson's Destroyer, that hurls from pneumatic guns shells charged with hundreds of pounds of dynamite, have been exhaustively treated in an article on "Modern Aggressive Torpedoes," by Lieutenant Hughes, U. S. Navy. Of the *defensive* torpedo, which is, as a rule, fixed in position, always controlled from shore stations, and is now an essential auxiliary in coast defense, but little has been written. The journals have at times published brief notices of the experimental work at the Willet's Point Station, while the "Official Reports of the Chief of Engineers" are inaccessible to the majority of the public. The main object of this paper is, therefore, to fill this field, and to lay before its readers a comprehensive sketch of the defensive torpedo system,

Though "mine ships," or "infernal machines," were previously used, it was not until the close of the eighteenth century that the fundamental principles of submarine torpedo warfare were grasped and practically studied.

To three native born Americans must be conceded the credit of inaugurating and experimentally establishing the value of the water cushion, of utilizing the pressure of water to develop the requisite intensity of action in a submarine explosion near the vessel to be destroyed, and of showing the possibility of employing the electrical current as an igniting agent that would hold the submerged torpedo, however distant,

always under the control of the operator.

During the Revolutionary struggle with Great Britain, David Bushnell of Saybrook, Conn., captain-lieutenant of sappers and miners, originated the first submarine boat, called the Turtle, of which we have any trustworthy record. Though it was never successfully used, yet in an attack upon the Eagle, an English 64-gun ship, anchored off Governor's Island, in the latter part of June, 1776, the navigator, Ezra Lee, sergeant of a Connecticut regiment, succeeded so far as to arrive in safety under the bottom of the vessel, when the magazine screw, instead of perforating the sheathing, unfortunately struck an iron plate near the stern, which, with the strong current and lack of skill in the operator, frustrated the enterprise, for daylight had too far advanced to renew the attempt. The boat returned to shore and the abandoned magazine drifted into the East River. After one hour, the time the internal apparatus was set to run, it exploded with great violence.

Undaunted by the failure of the Turtle, Captain Bushnell contrived another ingenious expedient to effect his favorite object. In December, 1777, a number of kegs charged with powder and arranged to explode on contact were set afloat in the Delaware River above the English fleet. Unfortunately the proper distance from the shipping had not been well ascertained and they were finally obstructed and dispersed by the floating ice. They approached, however, in the daytime, and one of them blew up a boat, and others exploded, which occasioned among the British the greatest alarm and consternation and precipitated the "Battle of the Kegs," described by a Philadelphian, in a letter to The New Jersey Gazette, January 21, 1778.

CIRCLE HOLDING CRUSHER GAUGES AT RIM AND EXPLODING CHARGE AT CENTRE, STATIONARY SUBMARINE MINE ON THE LEFT.

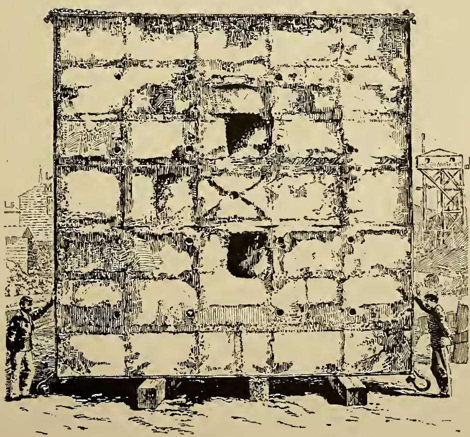
Robert Fulton not only improved upon and developed Bushnell's *offensive* machines, but to him alone is undoubtedly due the credit of originating the use of *defensive* torpedoes anchored to obstruct the channels and fairways of harbors. In 1809 he operated successfully with his submarine boat, Nautilus,

diving, attaching and exploding a torpedo charged with twenty pounds of gunpowder under a small vessel, which was completely destroyed. In March, 1810, he submitted to Congress detailed projects for closing harbors and mouths of rivers with lines of torpedoes, anchored and floating below the surface of the water. The fuse in this case was a short musket charged with powder, and it was expected that the shock of the vessel would snap the trigger, fire the charge in the barrel, and explode the torpedo. Other ingenious apparatus was also submitted for offensive operations. A "harpoon torpedo," for attacking vessels at anchor, consisted of a harpoon about two feet long attached by a fifty-foot line, to a torpedo which was buoyed to float on the surface of the water. The harpoon was to be fired from a gun into the bows of the hostile vessel; the current then swept the torpedo under her keel, and the snapping of a gunlock exploded the charge.

"Drifting torpedoes" were two buoyant mines connected by a line. They were submerged at a fixed depth and cast into the current to drift across the bows of the anchored vessels. The coupling line, fouled by the ship's cable, caused them to dive under her bottom, and the trigger, released by a lever, struck fire from the flint and an explosion followed.

Finally, Colonel Samuel Colt, in 1841, demonstrated the feasibility of igniting explosives under water by means of voltaic electricity. His ideas were, in truth, the offspring of Fulton's plans; but the birth and rapid advance of electrical science enabled him to produce far superior apparatus, and to formulate a system which would bring within the control of the operator torpedoes planted many miles from the igniting agent. The following passage from one of his letters addressed to President Tyler indicates an assured faith in the practicability of his projects:

"Discoveries since Fulton's time, combined with an invention original with myself, by means of which a passing vessel would communicate the fact of its presence in the sphere of activity to the home station and close the circuit in the case of the torpedo, enable me to effect the instant destruction of either ships or steamers at my pleasure, on their entering a harbor, whether singly or in whole fleets, while those vessels to which I am disposed to allow a passage



TARGET SHOWING EFFECTS OF EXPLOSION.

TORPEDO EXPLODED BY ELECTRICITY.

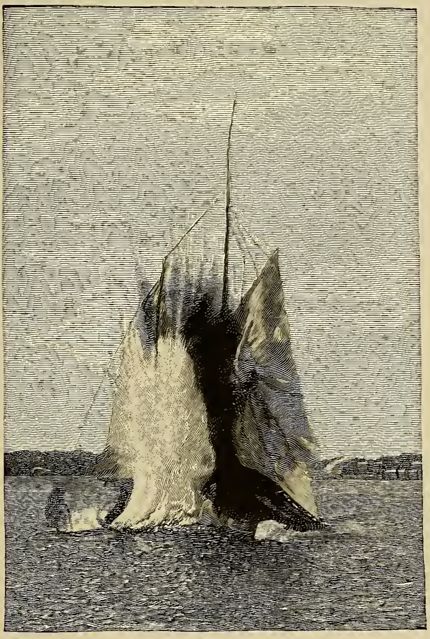
are secure from the possibility of being injured. All this I can do, while myself in perfect security, and without giving an invading enemy the slightest sign of his danger. The whole expense of protecting a harbor like that of New York would be less than the cost of a single steamship ; and when the apparatus is once prepared, one man is sufficient to manage the destroying agent against any fleet that Europe can send."

This system was practically demonstrated in 1842 by the destruction of the brig Volta in New York harbor ; while in 1843 he succeeded, with one of his torpedoes, in blowing up, on the Potomac River, a ship of five hundred tons. The vessel was at the time under way, running free before the wind at the rate of five knots per hour. The operator was stationed five miles from the torpedo, which was placed in the circuit of two insulated wires leading to the electrical apparatus.

From 1848 to 1860 but little improvement was made in torpedo material. Barrels daubed with pitch and tar, or sheet-iron cylinders studded with rivets, were used for cases. Either pattern proved far from waterproof, and the torpedoes, with charges damp or water-soaked, failed to respond to the electric spark or sank to the bottom water-logged and inert.

Substantial progress was made, however, in the methods of submarine defense. During the Crimean War the coasts of the Baltic and Black Sea were efficiently protected by lines of electric torpedoes planted in *quincunx* order; and the harbors of Sebastopol and Cronstadt were defended with contact torpedoes containing an apparatus for ignition far superior to the obsolete gunlock and trigger makeshift. Two glass tubes, one containing sulphuric acid, the other chlorate of potash, were placed one within the other and covered with a heavy block of wood; the shock of the passing vessel broke the glass, allowing the acid access to the potash salt, and explosion immediately ensued.

The Austrian-French War of 1859 marked the introduction of high explosives that were soon to supersede gunpowder in submarine warfare. The harbor of Venice was successfully defended by torpedoes charged with four hundred pounds of gun-cotton, in which was placed an improved fuse very similar in detail to those now in use. The insulated wire leading to the firing station was cut, both ends were passed through a small wooden block and reunited by a fine platinum wire, which was covered with meal powder and en-



EXPLODING MINE UNDER A SCHOONER AT WILLET'S POINT.

cased in a stout paper shell. The passage of the voltaic current heated the fine bridge, flashed the priming, and exploded the charge.

The prominent position the torpedo now holds as a most important and legitimate function of modern warfare is, in a great measure, due to the extensive and successful development of the system during the civil war in the United States. From the very outset of hostilities the Government recognized the vital necessity of closing the ports and inlets of the Southern coast. To maintain an effective blockade of a line nearly four thousand miles in length, indented with countless bays and harbors accessible to the largest vessels, was an undertaking beset with many difficulties. All the energies of the navy were at once devoted to shortening this line. The forts seized by the South at the outburst of the war had to be retaken. The large sea-coast cities were needed as bases of operation for the invading armies, and the navigable rivers were of prime importance for the transportation of large amounts of supplies, and to serve as channels of communication with the armies of the interior.

An unequaled mercantile marine; innumerable lines of sound and river steamers; numerous ship-yards from Maine to Baltimore, employing a large force of skilled workmen, had placed upon the oceans a fleet unequaled among maritime nations; the iron foundries and machine-shops of Pennsylvania and New York, capable of furnishing the most approved marine engines and armor-plating, impervious to the missiles of that period, supplemented with Yankee ingenuity and push, soon enabled the Government to control a fleet of nearly seven hundred vessels, which, starting with the stanch old man-of-war ribbed with oak and encased with teak, and developing the tin-clads of Vicksburg and Island No. 10, culminated in the little Monitor, the forerunner of the huge floating citadels of war which now hold the supremacy of the seas.

The South was unable to cope with the North on the sea. The works in their possession were, for the most part, armed with guns of low power and restricted range, of little avail against iron-clads, excepting in a prolonged artillery duel at close range; while the wooden vessels, swift steamers with low free-boards, ran past their batteries with impunity and remained under fire for only a brief period. This, then, was the problem they were called upon to solve: So to obstruct the navigable waters that channels, rivers, and fairways could at will be rendered impassable to the enemy and a haven to their own vessels; to provide barriers capable of holding the swift-going steamers under the fire of the batteries, and to devise means of attacking and destroying heavily armed iron-clads, impregnable to the armament of the forts. The solution was found in defensive torpedoes, aided and abetted by submarine boats, torpedo launches, and all such similar devices which the taxed ingenuity of a cornered combatant could contrive.

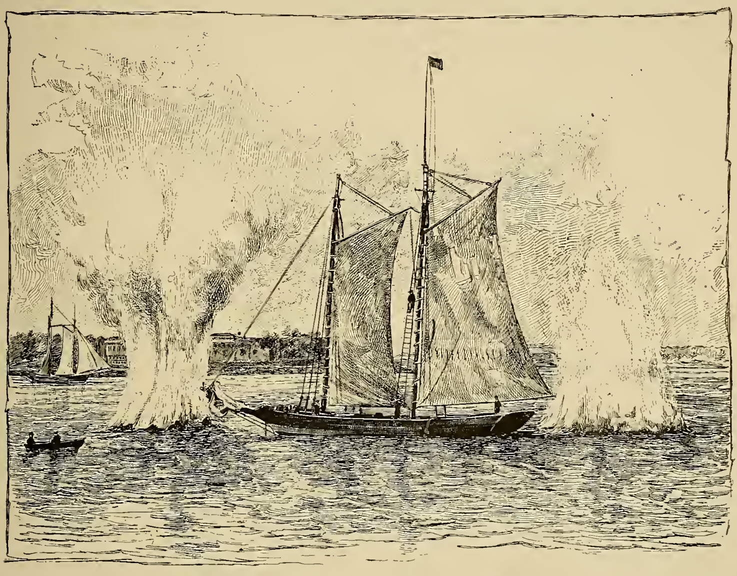
During the earlier stages of the war, defensive torpedoes were alone employed. Unwieldy in form and supplied with crude means of ignition, they passed from control as soon as planted, and barred the passage to friend and foe alike. Undaunted by repeated failures, and convinced that substantial results could be only obtained with a submarine service organized on a large and comprehensive scale, the South, in October, 1862, established a secret torpedo corps. The personnel was carefully selected. To stimulate individual endeavor, rewards were offered for the destruction of Federal vessels. Projects, apparatus, and inventions of all kinds were invited and carefully examined. Means were rapidly pushed forward to obstruct the channels of the principal harbors. Rivers and inlets were closed with electrical and spar torpedoes, and submarine boats were prepared for offensive operations.

The configuration of the Southern coast led to the invention and adoption of many types of defensive torpedoes.

Pile or *frame torpedoes*, for use in

shallow water, were metal cases spiked to piles driven into the bed of the river for that purpose; the charge was seventy-five to one hundred pounds of gunpowder, in which was imbedded a detonating fuse. Sometimes a series of these torpedoes were united by wooden frames stretched from pile to pile, thus increasing the obstruction. No well authenticated case records the destruction of vessels by this type of torpedo, but it was reported that the monitor Montauk narrowly escaped destruction by the explosion of one of these pile-mines during the attack on Fort McAllister.

Barrel-torpedoes were kegs anchored and buoyed to float a few feet beneath the surface of the water. A friction primer attached to a shore line was imbedded in the charge, ranges were established to indicate the position of the torpedo, and as soon as a vessel passed within the sphere of activity the line was pulled and explosion followed. The first substantial success scored in the submarine branch of this contest is due to this type of defensive torpedoes. In December, 1862, a fleet of gun boats and iron clads was despatched up the Yazoo river to capture or check the erection of masked batteries on the banks, and to remove obstructions from the bed of the river. Torpedoes were found and raised without difficulty or fatal results, and the fleet steamed through the dangerous zone reckless of the hidden enemy. A substantial blow, nevertheless, was dealt when least expected; for the iron clad Cairo, leading the advance, was torn asunder and sent to the bottom in twelve minutes by the explosion of one of these rude torpedoes.



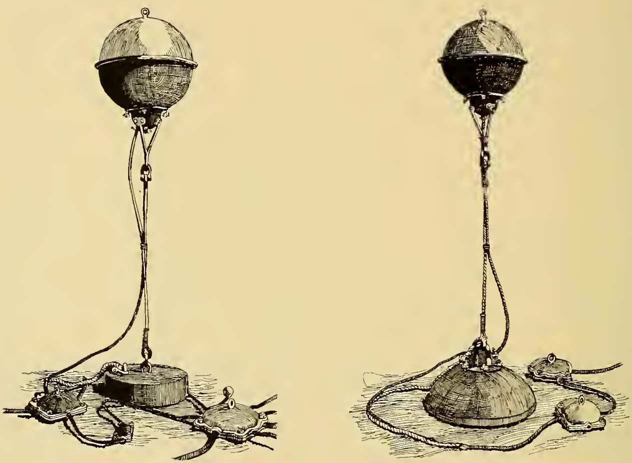
EXPLODING MINES ON BOTH SIDES OF A SCHOONER.

The *spar-torpedoes*, specially adapted for river defense, were elongated iron shells, percussion capped, and bolted to the end of booms that were shackled

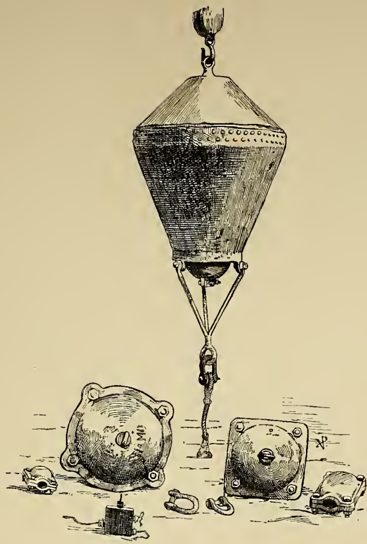
to mud anchors, and, swaying with the current, presented a formidable front to vessels ascending the river. Like the pile device, the defensive spar-torpedo can be credited with inflicting but little actual damage. But it retarded the advance of hostile vessels, and valuable time was lost in dragging for and removing this obstacle. To render their removal extremely hazardous, the ends of the several spars were connected by a wire with the percussion fuses of the neighboring torpedoes, so that the dragging boat, when attemping to raise a fouled spar, pulled the wire, detonated the charge, and proved her own executioner.

Electrical torpedoes. In this class electricity was employed as the igniting agent, and, for the first time, an attempt was made to so construct the fuses and arrange the apparatus that it might be always possible to test the intact condition of the connections, so that any break in the conducting wires or deterioration of the fuse could be readily ascertained. The cases were constructed of three-quarter inch boiler iron, and were of sufficient capacity to contain from two thousand to five thousand pounds of gunpowder. Although this type of defensive torpedoes was very extensively used during the latter part of the war, but one iron-clad, the Commodore Jones, was destroyed through its agency, in May, 1864, on the James river.

Although electricity had been employed as the igniting agent by Colonel Colt in 1842, in the Crimean War of 1855, and in the defense of Venice of 1859, the science of generating and measuring the electric current was yet in its infancy. Harnessed and led to its work, electricity often burst all bounds and escaped from control when called upon for a supreme effort. The escape of the New Ironsides, in an attack on the forts in Charleston harbor, is an apt illustration of this point. She cast anchor directly over an enormous torpedo planted in six fathoms of water and charged with two thousand pounds of gunpowder. The fuse was connected with a frictional electric machine on shore through insulated wires, and apparatus for electrical measurements was arranged in the circuit, by which daily tests were made. Notwithstanding these seeming precautions, and although the



BUOYANT SUBMARINE MINES WITH ANCHORS AND CONNECTIONS TO ELECTRIC CABLES.



BUOYANT SUBMARINE MINE, ANCHORS AND ATTACHMENTS.

vessel remained in this critical position for some hours, all attempts to explode the mine failed. It was said that the priming of the fuse had been damaged by repeated testing, but it is more probable that the fault lay in the connections or the insulated wires.

With the close of the civil war it may be fairly held that torpedo warfare had passed into the second epoch of development. The terribly destructive power of submarine mines had been fairly demonstrated. Vessels had been sent to the bottom, iron-clads, careless in their invulnerability to the missiles of the foe, had succumbed, as Goliah of old, to the insidious assaults of the intrepid Davids that stole upon them under the pall of night, or hidden under the surface of the waters. Unheard, unseen, the unexpected blow, hurling numbers to destruction, demoralized, unnerved, and lowered the *morale* of the navy. Many a well-weighed plan of attack was either postponed, or entirely frustrated, by a well-planned torpedo defense. No systematic plan of torpedo operations had as yet been evolved, but the value of such a defense was fully recognized. Channels, rivers, and inlets were defended by innumerable torpedoes, for the most part self-acting and fatal alike to friend and foe. Harbors were closed by immense submarine mines controlled and ignited by the electrical current, but independent of each other and lacking in concerted action. Submarine navigation, advancing *pari passu* with scientific research, gave promise for the future and stimulated the inventor to renewed application. Torpedoes were no longer regarded as mere accessories—a *dernier ressort* of a feeble power—but were now recognized as essential features of a well ordered defense of the sea-coasts.

Fully impressed with this view, the United States, in common with most European nations, established schools of research and application—at Newport for the navy, and at Willet's Point for the army. To the latter was confided "the establishment and mainten-

ance of torpedoes, to be operated from shore stations, for the destruction of an enemy's vessel approaching the shore or entering the channels and fairways of harbors." And the duty of developing and applying this system was assigned to the engineer corps of the army, who were specially qualified for such work by their military duties as miners and pontoniers, and their employment upon the national works for the improvement and protection of the rivers and harbors.

To formulate the methods and to devise means of filling the diverse requirements of a perfect defensive torpedo system in all its ramifications necessitated a vast amount of practical experimental work and scientific investigation. The destruction of vessels was now to be effected through the agency of subaqueous explosions, induced by compact charges of the nitro-glycerine compounds, and this led to a critical investigation of the general laws governing the action of these forces.

First in order, a series of experiments was undertaken to determine the relative intensity of action of these modern explosives. No little labor was bestowed in devising apparatus to accomplish these measurements. Approximate results were not sought, but an absolute record of the crushing blow hammered on each square inch of surface by these modern Titans. Tin cases containing from ten to twenty pounds of the explosive, in which was imbedded suitable fuses attached to insulated lead wires, were suspended and centred in an iron ring five feet in diameter. The ring was then submerged to a depth of thirty-five feet and the charge detonated.

Six dynamometers, held rigidly in position at regular intervals on the inner edge of the circle, registered the work performed by each shot. Nitro-glycerine, dynamite, atlas, Judson, and picric powders, gun-cotton, forcite, explosive gelatine, rack-a-rock, and many other varieties of high explosives, were so tested, with a view to selecting the type best adapted to the torpedo service. Primarily great power in a small space was sought, for a compact charge of minimum weight and bulk reduced the size of the torpedo-case and the weight of the moorings, a matter of prime importance in deep water and swift currents.

This point settled, other vital characteristics were studied. In so variable a climate, ranging from arctic cold to torrid heat, the charge should be susceptible of detonation in a frozen state and remain secure from decomposition under a Southern sun. Detonation should not ensue from ordinary shocks, as torpedoes are frequently exposed to the blows of friendly vessels, while the explosive force should be in no degree reduced when the compound is saturated with water.

Dynamite, in a great measure, filled all these conditions and was finally adopted for the defensive system.

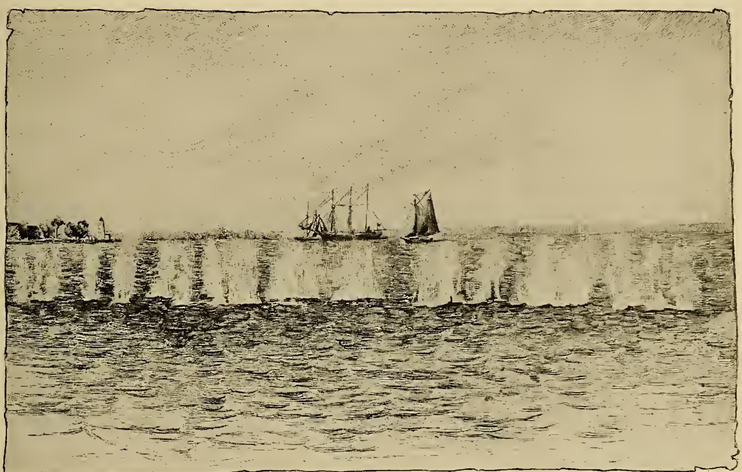
A series of interesting trials was now undertaken to determine the boundaries of the dangerous zone and to estimate the pressure necessary to crush the bottom of an armored man-of-war. An iron target firmly braced and ribbed, and constructed on the double cellular principle of the modern iron-clad, was subjected to repeated shocks of explosives detonated at varying depths and angles, and the value of the water-cushion to transmit the immense power developed by the quick expansion of the gases was fully demonstrated. The towering column of water that follows the explosion of a charge lying nearly at the surface, is no criterion of its efficiency; but proves, on the contrary, that much of the energy has been misspent. It was further shown that the effect of a horizontal blow was very much less than that of one delivered directly perpendicular to the bottom of a vessel. An eighty-ton schooner similarly assaulted, abow, astern, from starboard quarter, and from port, sustained no damage; but finally succumbed to a *vertical* blow dealt by a torpedo slung amidships under her keel, and was hurled into mid-air enveloped in a foaming spout of muddy water.

Photography, especially the instantaneous process, proved a very useful ad-

junct in this connection ; so much so that a laboratory was erected and stocked with cameras, chemicals, and other necessary appliances, and a special study was made of that branch of the art. The volume of water displaced, the height of the jet, the diameter of the crater, and all the phases of an explosion, follow one another so rapidly that the eye does not catch, or the mind record, the successive phenomena, but retains only a symmetrical and completed picture ; but the instantaneous ray catches and indelibly records the simultaneously exploded the torpedo and the camera fuse ; while through a minute aperture in the shutter, as it shot into place, a sunbeam penciled the picture on the sensitive plate.

The energy developed by the various nitro-glycerine compounds was thus measured, compared, and tabulated ; and the actual crushing effect of the blow they could deliver was ascertained in foot-pounds.

The type best adapted to this service having been then determined, the initial point was secured ; and next in



EXPLODING A LINE OF MINES.

changes passing in one-sixtieth part of a second. The destruction of the schooner and most of the other illustrations were so taken, by means of an ingenious arrangement that placed the camera in the same circuit that carried the electrical current to ignite the charge in the torpedo. The exposer shutter excluding the light from the lens was hung suspended in place by a fuse that cut into the wire connecting the break-circuit key and the charge. A tap on the key closed the circuit and released the electrical current, which order came the selection of a case to contain the charge. The time-honored wooden barrels were at once discarded, as they became water-logged and worm-eaten after a comparatively brief submersion ; and spherical shells of wrought iron, provided with an excess of flotation to hold the explosive near the bottom of the hostile vessel, were adopted for buoyant torpedoes ; while for ground mines, which were to rest immobile upon the bottom in shallow water, a heavy case of cast-iron, too low and flat in form to obstruct the move-

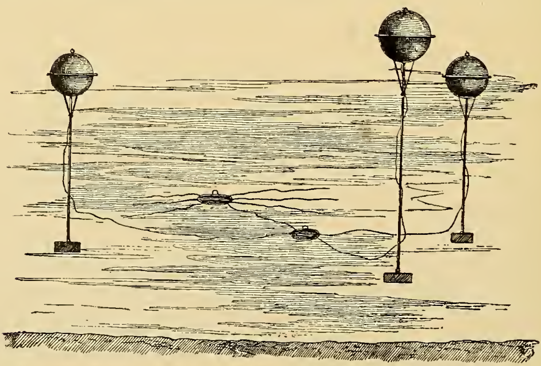
ments of our own vessels, was preferred. Above the cases and below the water surface float spherical buoys containing an automatic adjustment for igniting the charge when struck by a vessel.

The cases of the buoyant torpedoes contain a similar mechanism to open or close the electrical circuit. This circuit contains a fuse bedded in the charge, and is extended to shore through armored cables that enter galleries opening into a secure casemate, where is stationed the operator and apparatus. This apparatus consists of a powerful firing battery, which will ignite the fuse if allowed to send a current through it, and a second battery too feeble to endanger the fuse, but strong enough when flowing through the connections to operate a relay that automatically switches the firing battery into the circuit and explodes any torpedo struck by a vessel. This second battery stands constantly on watch, and not only controls the firing current, but operates an electrical signal that promptly announces any deterioration in the connections.

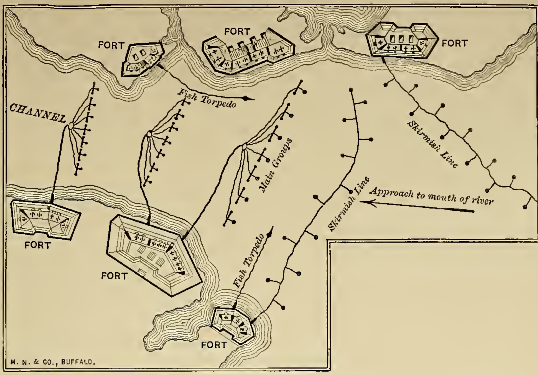
By connections with the relay wires leading to the electrical primers of flanking guns, trained by day to sweep the position, any injury to the torpedoes or connections that the enemy may succeed in effecting under cover of a fog or by night is instantly reported and his presence and locality indicated. This draws the automatic discharge of the pieces and rains upon the meddling boats an overwhelming volley of canister and case-shot.

Fuses of peculiar construction—armored cables affording a secure route for the electrical current, voltaic batteries, dynamo and electro-magnetic apparatus, firing relays, rheostats, galvanometers, instruments for electrical measurements and for testing the condition of torpedo and connections, plans for bomb-proof operating casemates, tunnels to secure the cables and their branches from the missiles of the foe, electric search-lights, conning stations, and a complete but simple telegraphic code—crowned these labors and placed at the service of the country, for the first time, a complete defensive torpedo outfit.

It only remained to perfect a plan for the disposition of the submarine mines, as torpedoes are now called. The principal harbors and inlets on the coast that command the great commercial cities, manufacturing centres, and navy-yards, and the great rivers whose branching arteries bear the agricultural fruits of the West to the East, were carefully surveyed, and the proposed position of groups and lines of mines to obstruct the channels far to the front and well to the rear of the shore defenses were located.



BUOYANT TORPEDOES READY FOR EXPLOSION.



METHOD OF PROTECTING HARBOR.

So thoroughly had the system been developed, each step proved by practical trial, eliminating the countless uncertainties fatal to the earlier methods, that all these branching lines of mines can now be tested, measured, and controlled from a central station overlooking the channel and approaches. Each main cable carries a group of twenty-one mines placed regularly in sub-groups of three, which are controlled through separate electrical conductors. The mines are independent in action and so connected that they are individually responsive to a blow from a hostile vessel, and each will explode without injuring the efficacy of the others ; while any sub-group can be fired at the will of the operator on shore, who can instantly open the passage to a friendly fleet, and immediately render it dangerous to the enemy by a skillful manipulation of the switches controlling the electrical current. Lines of irregularly disposed skirmish mines extend the area of danger far to the front—sentinels alert and vigilant—continually menacing the torpedo searchers of the enemy.

That submarine mines and heavy batteries are complementary is now fully recognized. So defended, a passage by force would never be attempted. To destroy the offensive power of the batteries by bombardment, or by countermining to open an unobstructed passage to the fleet, would but invite the attack of another insidious submarine foe ; unseen, noiseless in its approach, the *fish-torpedo* would dart forth under cover of the smoke of battle and, reckless of guard-booms, grape-shot, or shell, deal a fatal blow when least expected.

The Sims electrical torpedo might well prove a valuable auxiliary to the fixed mines, and is properly classed in the defensive torpedo system, as it is actuated and controlled from the fortifications that defend the fairways and approaches to our harbors. Popularly known as a "fish-torpedo," from its shape and facility of movement under water, this engine of destruction is essentially a submarine boat, cylindrical in form, with conical ends. A float opposing but little surface to any missile, and filled with a buoyant substance nearly impervious to water, supports the hull, in which is carried the explosive charge, the steering relay, a drum of cable, and the electric motor that actuates the screw-propeller. To enable the pilot to follow the track of the torpedo, and change her course as circumstances may demand two rods showing colored balls or electric lights are placed fore and aft on the almost invisible float. These rods are held at the base by a spring hinge so as to assume a horizontal position when moving under an obstruction, and to recover their upright position when the obstacle is passed.

Propelled, steered, and exploded by electrical power, the current is generated by a dynamo-machine secured in a bomb-proof shelter, and is conveyed to the motor through the insulated cable, that pays out freely as the boat proceeds on her deadly mission. Started, stopped, or steered to port or starboard at the will of the operator on shore, obstructions may be avoided ; or, if met, a sharp steel blade running from float to hull at bow and stern would cut through cables, ropes, and netting, or cause the "fish" to dive under booms and rafts that may be placed around vessels to impede her course. The crucial tests to which this torpedo was subjected are narrated in the following brief *precis* from official reports :

"On September 19, 1882, the float of the torpedo was anchored in front of a 32-pound howitzer. It was fired at five times at a range of 370 yards, and eight times at a range of 186 yards, with double-shotted canister charges, each containing ninety-six balls. Five large holes were made by this firing. The float was then towed about a mile by a steam-launch at a rate of five miles per hour. On its return it had lost only 150 pounds of its 400 pounds buoyancy, and was perfectly serviceable for use in an attack.

"On October 26, 1882, experiments were made to test its power of resisting concussion. The mast of a schooner, fifty-six feet long and seventeen inches in diameter at the foot and thirteen inches at the head, was anchored by two 500-pound anchors—one at each end. The torpedo was driven against this obstruction twice, once moving at the rate of seven and a half miles per hour, and once at nine and a half miles per hour. Neither shock did any damage. The torpedo in both cases dived under the log and continued its course uninjured."

These tests sufficiently prove that the torpedo is quite safe against any artillery fire which it would encounter in actual service, and that no temporary protection, in the shape of spars or logs moored around a vessel, would be of any value against an attack.

Self-acting mines, which pass from control as soon as planted, find only a limited application in the modern system. The cases and explosive charges for this type are similar to those used for the buoyant electric mines, but they differ greatly in the mode of ignition. Sometimes this is purely mechanical ; one pattern contains a very sensitive priming, which is ignited by the pressure transferred to it through a thin cap of copper or lead when struck by a vessel. Another pattern contains a mixture of potassium chlorate and sugar around a glass tube filled with sulphuric acid ; the latter is broken by the shock of the contact, and the acid ignites the priming, which, in turn, fires a train of gunpowder leading to the charge.

A later form, known as the Russian mine, is provided with cylindrical projections containing potassium bichromate in glass tubes ; when one of the latter is broken by the vessel the fluid flows into a lower compartment of the plug containing the plates of a voltaic battery ; the battery thus formed sends its current through a curcuit in the torpedo containing a fuse, which, exploding, detonates the charge. Other patterns are provided with a break in the curcuit, which is automatically closed after the mine is planted by the dissolving of a piece of sugar, or by some similar device.

European nations, working in parallel lines to a common end, have formulated methods and devised means of torpedo attack and defense fully as complete as that of the United States. No longer stigmatized as *barbarous* and *inhuman*, the "infernal machine" of the last century now claims a place in civilized warfare. While always ready to deal the fatal blow, it is perhaps most effective when, silent and inert, it stands on guard, and, credited with almost supernatural powers, throws around the threatened zone a circle the enemy does not dare to enter.

LONG DISTANCE TRANSMISSION OF POWER.*

By Charles S. Bradley.

IT is supposed that there was a time when man did not know of fire; that it was a discovery, and great must have been the discoverer among his fellows if they did appreciate the importance of combustion, as we now call it. Without it, man could not exist in these colder climates and must have hovered about the equator. It now not only provides us with a means of comfort in the winter's cold, but also gives us light and power. The last decade has given us this light and power in much improved form by the aid of that silent mysterious agency—electricity. If one has to go into the woods and cut his own wood to keep warm, almost half of his time is taken up in the chopping and hauling; so, too, in supplying the fuel to a steam engine, much labor of human hands is required, especially if the source of fuel is distant from the point of use. By organization, by careful preparation and the construction of permanent works, how wonderfully man increases his comforts and reduces his hours of toil. If a man were to try to light his house with incandescent lamps, and do it with his own power, his whole energy would be consumed in one light. If he were to try to propel his own lathe he could turn but a small one and leave himself no leisure time. It now lies within our means to build an electric transmission of power plant from coal mine to city, which shall cost $300,000, and will transmit 5000 horse-power; this plant will do the work of 30,000 men steadily day and night, year in and year out, and once placed will last a lifetime. The $300,000 represents the work of the 30,000 men for about four days, or an outlay of $10 each; thus these men can build a plant in four days that will do more work during their whole lives than they can. Can anything appeal to the imagination of man with more force? The energy of 5000 horses transmitted noiselessly over a small wire, the coal from the mine placed by one act immediately beneath the boilers, the energy thence running to its destination without any labor from man; the air to supply combustion taken in the country, thus not robbing the human being gasping for breath in the city; the smoke and foul gases being thrown off where they will do no harm. Think of a city free from smoke, its cars, elevators, shops, run and lighted by electricity which shall be generated miles away. I have not said houses heated, but I hope that before 1900 we may say this also. The present obstacle to heating by electricity is the inefficiency of the steam engine. Many are looking for the direct conversion of the energy of coal into electricity. There is no doubt that it can be done, but I fear it will never be economical, for we must depend upon the combustion of the coal in the oxygen of the air. The oxygen is just as necessary as the coal, but, being ever present, people neglect to consider how important it is. There is no other element in nature which can

*Paper read before the National Electric Light Association.

replace oxygen for this use. The only way we can get the energy at low cost is by the chemical combination of these two substances—coal and oxygen. The ordinary combustion where the air passes through the coal admits of the production of heat only ; for the electrical resistances, although the spaces may, by inventive genius, be made as small as the atoms themselves, will be so great as to prevent any commercial current from flowing. The thermopile offers a way to use heat, but when heat has once been produced we cannot expect to convert it to a higher form of energy without great loss. If we solve this problem, we must catch the energy as it issues from the chemical combination. The only way now known to man of converting chemical energy directly to electricity is illustrated in the primary battery, where a conducting electrolyte forms a path for the current, and at the same time carries the elements that are to be consumed toward each other. This to all appearance is inherent. It necessitates that the oxygen shall have abandoned the gaseous state and entered the liquid. The coal demands for working a high temperature ; therefore, the oxygen must have entered liquid condition and stays so at high temperatures. There are substances, such as permanganate of soda and the chromates, that seem to approach very close to filling these requirements as an electrolyte; that is, they will at high temperatures absorb oxygen from the air. They will also act chemically on the coal and produce a current. But now we are coming to the limitation again. The specific resistance of these substances is too high and the electromotive force too low, being between .9 and one volt, to give a reasonable amount of power from a given size of apparatus. The most promising of all fields to increase the efficiency of the conversion, I believe, lies in the gas engine; the atmospheric gas engine of Otto Langen having reached the high efficiency of seventy-two per cent. In this engine the piston is allowed to shoot up by the explosion and do its work in the descent. There seem to have been mechanical difficulties in the way of the success of this machine, but these can be overcome. Then, suppose we have an efficiency of seventy-two in an engine and seventy-five per cent. in transmission, we will have, all told, fifty-four per cent. of the energy of the coal delivered to point of consumption, which will make electrical heating not only possible but preferable to any or all other forms. Thus we may hope at no distant day to burn all coal necessary for the uses of a great city at the mine. Farther, we make take from the coal first its chemicals, which have become so valuable in the arts; then use the balance as gas in our engines.

For the electrical transmission of power we have two general systems—the alternating and direct. The multiphase alternating was advertised extensively by the Lauffen-Frankfort plant in 1891. The pioneer plant was built by much sacrifice of time and money, and we owe gratitude and honor to these men whose indefatigable efforts accomplished the beginning of an art which is destined to revolutionize the social status of mankind. This plant proved conclusively that very high voltages could be successfully used and the insulation maintained. This is the whole thing in a nutshell; the choice of this or that particular way of generating and using the energy is of secondary importance, and will vary with each situation; surprising as it may seem, the maintenance of the insulation was the least trouble in the operation of this plant. One of the greatest, the interference with the telegraph which belongs to the German government; and when the German government says : "Stop," it means stop (in Germany). The next difficulty in importance is the static induction; each wire, being so long and exposing so much surface, becomes a reservoir to hold electricity, and the generator must fill this reservoir on each impulse before it can deliver energy at the distant end. When the generator reverses the direction of current, as it does some 100 times per second in the alternating, this reservoir

must be discharged and filled with electricity of opposite sign; that is, if the first impulse to a given wire was positive and fills its capacity with the positive electricity, the reverse impulse must discharge the positive and then fill the reservoir with negative electricity. This operation consumes but little power; it is an ebb and flow, as it were. The trouble, however, is that this idle current swinging back and forth occupies the carrying capacity of the generating apparatus; so much so, that I saw the fuses blown at Lauffen with no load of consequence at the Frankfort end. In damp weather the insulators become wet on the external surfaces, and this largely increases the capacity, which is more serious than the increased leakage. These difficulties vary with the length of the line and the amount of power transmitted, the surfaces being proportional to the length of line. The carrying capacity is proportional to the square of the diameter of the wire, while the static capacity is proportional to the surface, which is equivalent to being proportional to the diameter, so that the larger the amount of current transmitted the less proportional influence the static capacity has. These things must be determined by the engineer in each case. The Lauffen-Frankfort was an extreme case. First, the line was much longer than we shall expect for some time to come in practical work; second, the plant was intended for 300 horse-power and a rate of forty phases per second. Owing to the static effects at forty, the rate had to be lowered to about twenty-three per second; this obliged them to run the dynamo at very much reduced speed, so that it was capable of only about 100 horse-power, and this reduction increased the proportionate effect of the static charge. In long distance transmission the lines should be carried on poles whenever it is possible, for the farther apart the conducters are, the less will be the inductive capacity; if placed under ground they will of necessity be near together. The placing in separate conduits to gain distance will not help, for the nearness of the earth is the equivalent of the nearness of the conducter of opposite sign. These things are only warnings, however, and slip out of sight with proper precaution. The multiphase alternating is the most pliable, adjustable system that has ever been conceived. It fairly entwines itself about the electrical engineer's heart. It is capable of transformation in voltage; will supply motors of either synchronous or non-synchronous type; will readily convert in motor transformer to direct current for electric railroad or direct current distribution, and thus supply direct current motors. A patent was issued to me October 2, 1888, which covers this ground, and it is surprising and gratifying to read the original specification filed April 23, 1887, now nearly six years ago, and note there the complete provision for the transformation for these varied uses. At the factory of the Fort Wayne Electric Company I have had exceptional facilities for experimentation on the multiphase systems, some 270 different tests having been made on motors, dynamos and transformers, the record of which fills a respectable volume. If this could be given to the world, that the engineers might know what not to do, undoubtedly the wings of many a genius would be clipped.

Where the power is to be delivered in compact form, the direct current offers some important advantages. We can get very high voltages by a battery of machines placed in series for the generator and motor stations. The placing of machines in series for power transmission was proposed by Mr. Edison in 1880 and Prof. Thomson in 1883. Each contributed some essential improvement, but it is evident that the enormously high voltages now contemplated were not then thought of. For the generator station I prefer compound wound machines; first, that the system may be self-regulating; second, that the series coil when a machine is thrown into action shall magnetize the field in the right direction; this also requires that the switch shall close the series coil

first. The shunt-coil would tend to reverse until the machine has attained electromotive force enough to overcome the resistance of its own armature. In order that each machine should be as far as possible independent of its neighbors, I prefer that it shall be short shunt, or in other words, the shunt coil be charged direct from the brushes of each machine. I would use the 500-volt machines, and of such ampere capacity as the size of the plant demanded, and belt them all from one shaft. The 500 volts have been found safe to life and the commutator works well. Now, we must protect the insulation of the windings ; the end machines where the terminal voltage, say, reaches 20,000 volts may, in case of grounds, be subjected to the piercing strain of the entire electrical pressure. It is impracticable to insulate the windings of each machine to stand any such potential ; therefore, we connect the windings of the machine at some point with the frame so that it may never be subjected to a strain greater than its own voltage ; next each machine foundation is thoroughly insulated from earth, and, in case this insulation fails for any reason, the fuses of the line will be blown, thus protecting the whole structure. It is easy, however, to make this foundation insulation so perfect that no derangement will take place. For this, I have struck upon a cheap plan, which was not apparent at first. Having now provided for the insulation, we must next consider the safe handling of the machines. A moment's consideration of the electrical potential of each successive machine in the series will make it evident that the whole of each machine will attain the potential of its individual position ; or, beginning at one end, each successive machine will be 500 volts above the preceding one. Now, it is a well-known fact that a man may be charged to a high voltage without any inconvenience. An illustration of this is found in the stool with glass legs that we used to stand on in school and be charged up until our hair stood on end. The danger to life comes from the passage of a current through the body. Now, like standing on the stool with the glass legs, a man may be placed upon any one of these machines, and if he cannot touch any conductor to earth he is perfectly safe. We can use a wooden platform around and attached to the base of the machine, so that the man must cross it before he lays his hand on the metal part. Here, again, I want to point out how essential it is that the windings be in metallic connection with the frame for the safety of the man. It secures that no part of a machine shall exceed its own voltage, and, in case of a leakage in the foundation insulation, immediate detection. If this metallic connection were not provided and a leakage occured in the foundation, you will readily see that it might be undetected, and a man touching the brushes and the frame would take a current through him of uncertain high voltage. At the motor station we use simple 500-volt shunt machines with the same precautions as at the generator station. Our power having been transmitted can now be converted into whatever may be demanded. If it is an electric system of distribution, we shall have the advantage of its being impossible for the high tension current to get into the system of distribution. If it is a large plant, the motor station may be subdivided into two or three parts, preferably in multiple arc, with the same potential on each. On very long lines I think the transmission must be done by direct current. To prophesy, although a temptation, is futile, for the lines of progress are not as one man would think, but as the multitude of surrounding circumstances determine.

MODERN GAS AND OIL ENGINES.

By Albert Spies.

First Paper.

GAS engines, at the present day, are common enough, the past ten or twelve years having witnessed the production of a host of designs, although of these probably by far the larger number have gained little more publicity than that afforded by the patent office records of different countries. But the more fortunate ones,—those that have been put into marketable shape and sold for a variety of motive power purposes,—have been sufficient to amply advertise this type of motor and to practically demonstrate its applicability to many, if not all, the uses to which the steam engine has hitherto been put. It would, therefore, seem almost unnecessary to more specifically define it as an engine in which the working fluid is an inflammable gas, or, more correctly, a mixture of atmospheric air and inflammable gas, introduced directly into the engine cylinder and there ignited and burned. All gas engines, while they may differ widely in theory of action and mechanical construction, possess in common this one feature of heating the working fluid in their cylinders proper. Compared with the steam engine as a familiar example, and with most hot air engines, we thus find in the gas engine relative simplicity in so far as no separate furnace is necessary in which to burn the fuel from which the energy is primarily derived; furthermore, the energy is available at exactly the moment needed, and there is no storing up of heat in the same sense as in the steam engine and boiler combination. Hence, it will be seen that the gas engine also has a special applicability in all cases where continuous work is not required.

Concerning the origin of the gas engine there is no definite information. By some it has been dated as far back as the latter part of the seventeenth century when gunpowder was proposed and used for obtaining motive power in special apparatus. These early engines, however, can scarcely be properly classed as gas engines. The first gas engine, in the now accepted sense of the term, was probably that patented in the year 1791, in England, by one John Barber. It provided for the use of coal, wood, oil or any combustible in a retort, the generation of vapor or gas from such combustible, and the collection and cooling of the gas in a reservoir. Thence the gas was taken to a compressor which supplied the motor cylinder, and in this latter the gas was mixed with atmospheric air in proper proportion, and exploded by a light. This engine embodied, in the main, the principle of the modern gas engine. Three years later, in 1794, Thomas Mead and Robert Street both obtained patents in England for gas or vapor engines, Mead proposing to raise the piston in his engine cylinder by the ignition of a gaseous, explosive mixture and to utilize for the down-stroke both the weight of the piston and the partial vacuum formed underneath it. This was, in part, the principle of the much later Otto and Langen engine. Street's engine, on the other hand, partly anticipated the also much later hydrocarbon engine of George Brayton, providing, as it did, for the production of motive power by introducing a few drops of spirits of turpentine into the heated bottom of a cylinder. The tur-

pentine was vaporized by the heat, air was mixed with it in sufficient quantity to produce an explosive compound, and a flame was applied to ignite it. The next patents for gas engines were not issued until nearly thirty years later (1823). From that time on they appeared at shorter intervals until more recently, when design crowded design in rapid succession, so that now the gas engine patents are numbered by the hundreds. The essential differences between the inventions, however, are not very great. In many cases, in fact, it seems sadly true that the inventors have been satisfied with producing simply some detail by which the original patents could be avoided, rather than anything which really marked a step in advance.

It would be impracticable to here follow the history of the gas engine in anything like detail from its earliest days to the time when it became justly looked upon as a distinctly practical and useful source of power. A few of the types, however, which, though comparatively crude and more or less imperfect, still came into somewhat extended use and practically opened up the era of commercially successful gas engines, deserve mention. The first of these was the Lenoir engine, made even at this date in a modified form, a machine of simple construction, and very similar in appearance to an ordinary horizontal steam engine. The piston moving, say, from the right to the left drew in a mixture of illuminating gas, or of hydrogen, and air through a slide valve worked by the engine. When a certain quantity of this mixture had entered the cylinder, the slide valve shut off the supply and an electric spark from an induction coil kindled the gas and caused an explosion which drove the piston to the other end of its stroke. Arrived there, at the left end, a second slide allowed the products of combustion to escape while the fly wheel, by reason of its momentum, went on and moved the piston in the opposite direction, from left to right. While it moved in this direction, the explosive mixture again entered and was ignited as before, and the piston completed its travel to the right under the impulse of this second explosion. The action, it will be seen, was thus very similar to that of the ordinary, familiar steam engine. To prevent overheating of the cylinder and piston, the former was surrounded with a jacket filled with cold water.

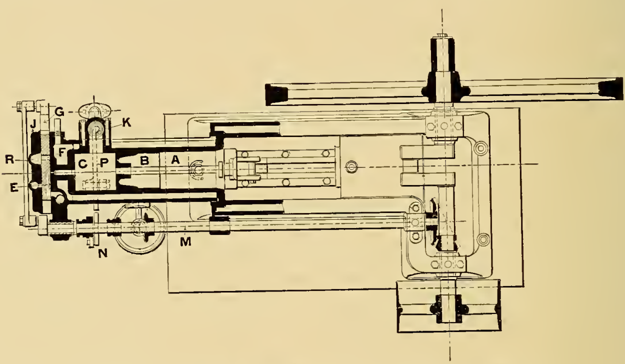


FIG. 1.—PLAN VIEW OF THE ORIGINAL OTTO SLIDE-VALVE ENGINE.

Following the Lenoir engine came that of Hugon, in which the tendency to become overheated was counteracted by introducing into the cylinder, together with the gas and air mixture, a

quantity of water which, in vaporizing, absorbed considerable heat and thus kept the temperature within a reasonable limit. The expansive force of the gases was in this way, it is true, somewhat diminished, but the moving parts suffered less, and the engine required less repair and was more durable. Ignition of the explosive charge was effected by a gas jet.

A number of years after the bringing out of both these engines, Otto and Langen together entered the gas engine field with what they termed their atmospheric or free piston engine for which they were awarded a gold medal at the Paris Exposition in 1867. The main features of this engine are briefly referred to further on.

The Brayton engine, an American invention, was first brought out in 1873. It had two cylinders, one being a compressor and the other a motor cylinder. The charge of gas and air was first drawn into the compressor cylinder on the out-stroke, and on the back-stroke was compressed into a receiver. The motor cylinder took its supply from the receiver, but the mixture was ignited as it entered, a grating arrangement preventing the flame from passing back. The mixture proper, in fact, did not enter the motor cylinder at all ; what entered it was a continuous flame and the action, therefore, was not explosive in character. At a certain point the supply was cut off, and the piston moved on to the end of its stroke under the influence of the expansion of the hot gases. The flame grating in this engine, however, was a weak point. If by any accident the grating or wire gauze was pierced, in cleaning for example, the flame went back into the receiver and exploded the whole stored-up mixture. Such accidents became so troublesome that Mr. Brayton after a time discontinued the use of gas and converted his engine into a petroleum motor. Light petroleum was pumped upon the grating and the compressing cylinder charged the receiver with air alone. The air, in subsequently passing through the grating, carried the petroleum along

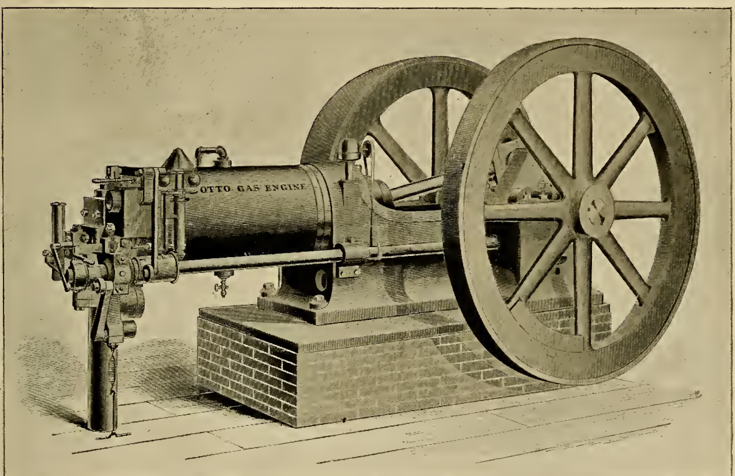


FIG. 2.—THE OTTO GAS ENGINE, BUILT BY SCHLEICHER, SCHUM & CO., PHILADELPHIA, PA.

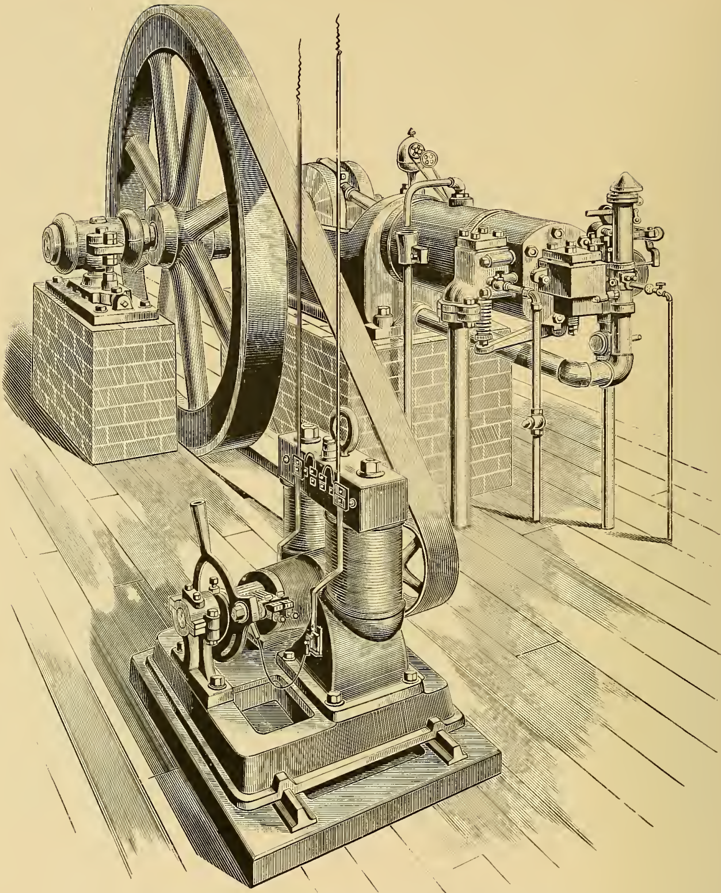


FIG. 3.—OTTO GAS ENGINE AND DYNAMO FOR HOUSE LIGHTING.

with it, partly in vapor, and partly in spray form. This oil vapor and air mixture was then ignited just like the previously used gas mixture. The arrangements, in fact, were precisely similar to those of the gas engine, except in the addition of a small oil pump and a slight alteration in the valve disposition. The engine, as may be understood, was single-acting.

Right here it should be pointed out that the similarity between the original Brayton gas engine and the converted Brayton engine using petroleum is typical, also, of all gas and oil engines of the present day. All the oil engines follow the lines of the gas engines very closely ; in fact, in some of the gas engines now on the market gas or oil mixtures can be used indiscrimi-

nately, the engines working well with either, and without modifications of designs to suit the particular kind of fluid used. A distinct classification into oil motors and gas motors cannot, therefore, be well made, and both may be, very appropriately, considered together under practically one head.

Broadly speaking, however, the various engines, early and modern, and using either gas or oil mixtures, may be divided into a few, well-defined types:

1. Engines drawing into the working cylinder gas or oil vapor and air at atmospheric pressure for a portion of the piston stroke, cutting off communication with the outer air, and igniting the mixture. The pressure of the ignited gases pushes the piston forward during the remainder of the stroke, and the in-stroke of the piston expels the products of combustion from the cylinder.

2. Engines in which a mixture of gas or oil vapor and air is drawn into a pump forming part of the engine proper, and discharging the gas mixture into a receiver or reservoir in a state of compression. From this receiver the mixture enters the motor cylinder, being ignited as it enters. The ignition here does not increase the pressure, but increases the volume. The pump, say, puts one volume or cubic foot into the receiver; ignition causes it to expand, while entering the cylinder, to two cubic feet. It does the work of two cubic feet in the motor cylinder, so that though there is no increase of pressure, there is nevertheless an excess of power over that spent in compression. The return stroke of the piston again expels the products of combustion.

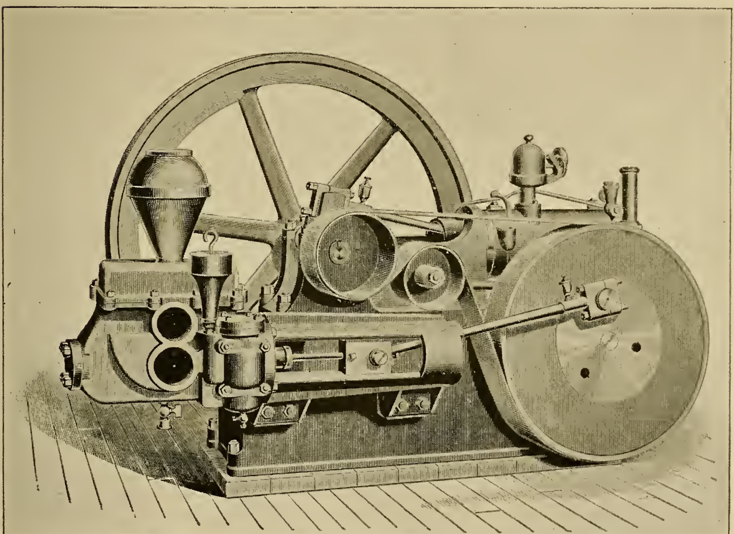


FIG. 4.—OTTO GAS ENGINE AND PUMP COMBINED.

3. Engines in which a mixture of gas or oil vapor and air is compressed, or introduced under compression, into the cylinder or space at the end of the cylinder, and is then ignited, the volume remaining constant and the pressure rising. Under this pressure the piston moves forward, and on its return as in

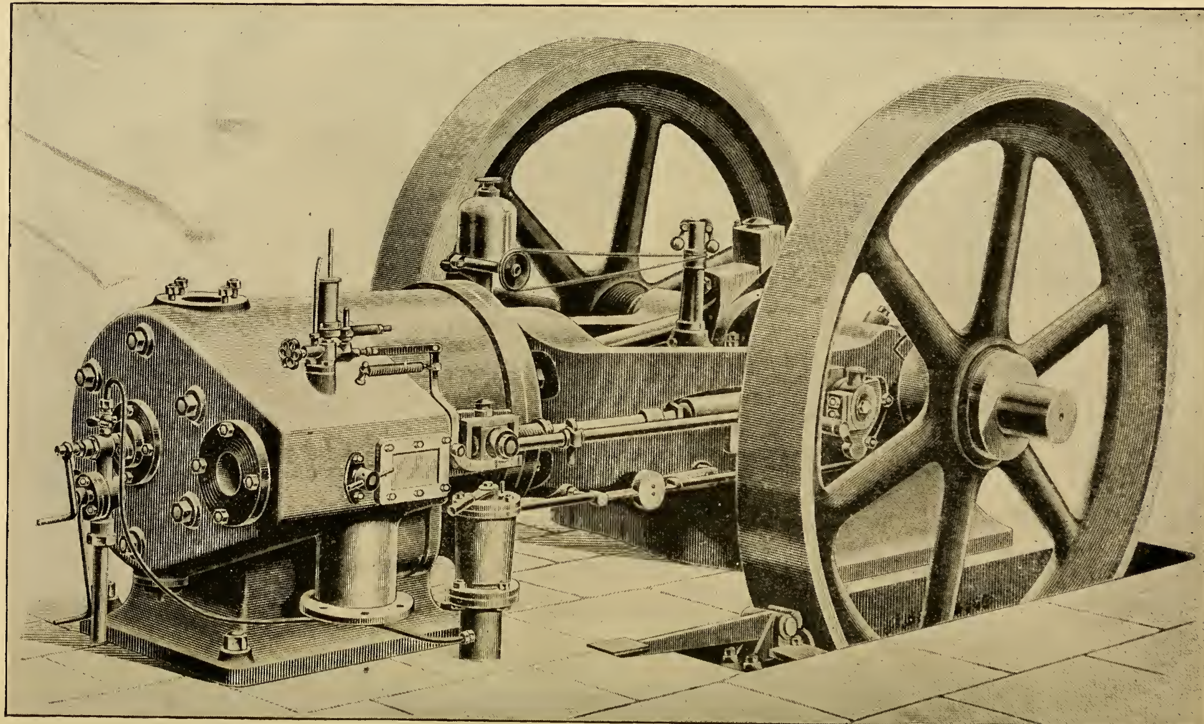


FIG. 5.—FIELDING'S GAS ENGINE, CONSTRUCTED BY MESSRS. FIELDING & PLATT, ENGINEERS, GLOUCESTER, ENGLAND.

the previous types, discharges the waste gases from the cylinder.

Types 1 and 3 are explosive engines, the volume of the gas remaining constant while the pressure increases. Type 2, on the other hand, is a gradual combustion engine in which the pressure is constant while the volume increases. The third type is generally regarded as the best kind of compression gas engine yet introduced, and by far the largest number of gas engines now in every day use are made in accordance with its requirements. The leading idea, compression and ignition at constant volume, was first proposed by Barnett in 1838, and later by several others, but Otto was the first to successfully apply it in 1876, in the now well-known engine bearing his name.

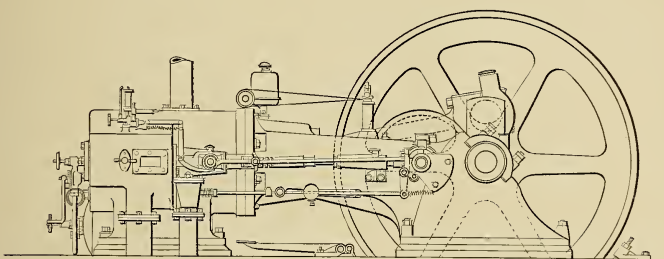


FIG. 6.—FIELDING'S GAS ENGINE. SIDE ELEVATION.

There still remains one important type of gas engine not included in this classification. It is the kind of engine known as the free piston or atmospheric gas engine already referred to above, and may be regarded as a modification of the first type. The first part of its action is precisely similar ; the latter part differs considerably from it. In this engine the piston on moving forward, takes in its charge of gas and air from without at atmospheric pressure and temperature. When cut off it is ignited instantaneously, the volume being constant and the pressure increasing. The piston is not connected directly to the motor shaft, but is perfectly free to move under the influence of the explosion, like a projectile in a cannon, for example. It is thus shot forward in the cylinder, which is purposely made very long. The energy of the explosion gives the piston velocity, and the piston therefore continues to move considerably after the pressure has fallen by expansion down to atmospheric pressure. Owing to this and to the cooling of the gaseous products a partial vacuum is formed behind the piston till its whole energy of motion is absorbed in doing work against the pressure of the outside air. It then stops and the external pressure causes it to perform its return stroke, during which a clutch arrangement connects it with the motor shaft, giving the latter rotary motion. The piston during its return stroke proceeds completely to the bottom of the cylinder, expelling the products of combustion. This kind of engine was first proposed in 1854 by Barsanti and Matteucci, but Otto and Langen, as previously mentioned, in 1866, were first successful in overcoming the practical difficulties in its way, and many engines were built by them for practical uses. The engine though cumbersome and noisy, was a good and economical worker, and many are probably still in operation to-day.

It is scarcely within the province of this article to take up the theoretical considerations presented by these representative types of gas engines. Suffice it to say that the causes of the comparative efficiency of the modern gas engine over the older forms, such as the Lenoir and the Hugon engines may be

summed up in the one word "compression." Without compression before ignition an engine could not be produced which would furnish power economically and with small bulk.

To the prospective user of a gas engine, the question of cost of operation, or more specifically the cost of fuel used for a given amount of power is, as might naturally be expected, one of the first to present itself. That the fuel or gas cost is unduly great has been, and is still, a more or less prevalent impression and the fact seems to have been largely lost sight of by many power users that the development of the gas engine from what was at first perhaps little more than an interesting novelty to a source of even large powers at the present day has naturally brought with it much increased efficiency and correspondingly reduced running expenses. Just what these expenses are, so far as they are affected by the items of gas quality and cost, of course depends much upon special circumstances. The price of gas as well as its quality varies with locality and time, and definite statements of cost can therefore not easily be given.

Professor Ayrton, in England, several years ago, in comparing the fuel costs of gas engines and of portable and semi-portable steam engines to determine the relative expenses in driving electric light dynamos, estimated that the steam engines in question would, in a competition, consume about four pounds of coal per indicated horse-power per hour, but that in ordinary work their consumption would run up to six and seven pounds. Assuming a four-pound basis, however, which seems pretty fair, and taking, for the sake of illustration, the price of coal as $5 per ton, we get for the cost of a horse-power for fuel in these engines one cent per hour. At the rate for gas, paid in London at the time,—three shillings, or about seventy-five cents per thousand cubic feet,—the cost of one horse-power in the gas engine would amount to one and one-half cents per hour. Taking the highest prices paid in London for gas,—four shillings, or about one dollar per thousand,—the gas would cost two cents per horse-power per hour. This makes a very favorable showing for the gas engine, which has so many advantages and economies, as compared with the steam engine, as to easily overbalance its slightly higher fuel cost. In the United States, where the prices for gas are considerably higher, the comparison of the fuel costs would, of course, be somewhat less favorable to the gas engine. Much, however, is to be expected both here and abroad, in the direction of cheaper heating gas, and there seems little

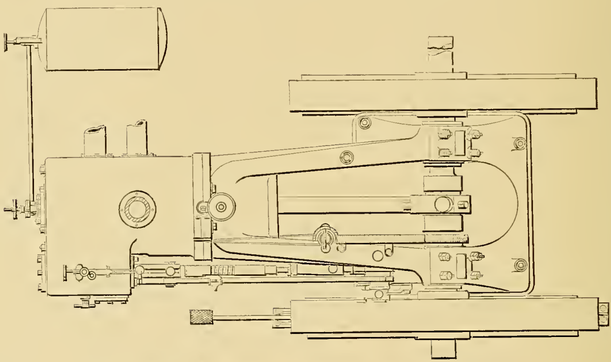


FIG. 7—FIELDING'S GAS ENGINE. PLAN VIEW.

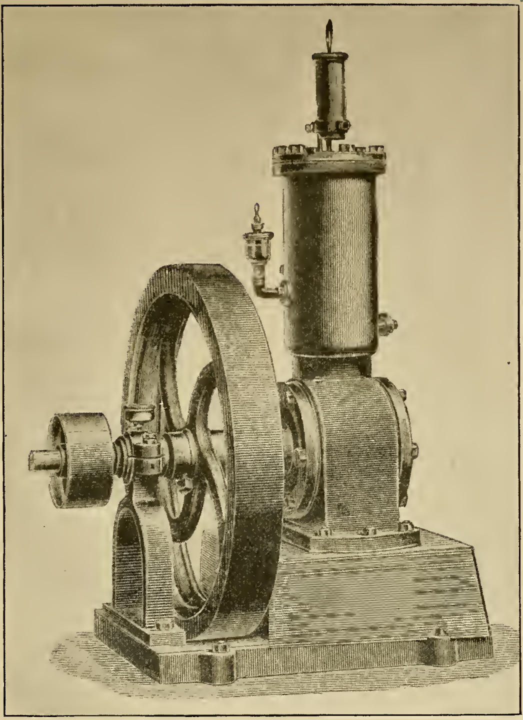


FIG. 8.—THE DAY GAS ENGINE. MESSRS. LLEWELLIN & JAMES, BRISTOL, ENG.

reasonable doubt that such a gas can be made and will probably be made in the near future, and will render the ordinary gas engine up to a certain size, much more economical in running expenses than an equal sized steam engine. Even as it is, however, with gas at the current rates, the gas engine in a great many cases foots up a smaller expenditure for a given horse-power than the steam engine. There is always a very considerable saving when standing still, and this, when the stoppages are frequent, may amount to a most appreciable total.

As a sample of what may be accomplished with a cheap heating gas we call to mind a low cost gas enterprise, started a number of years ago in the vicinity of New York City, by which heating gas was made on a large scale under the Strong patents. From figures that were received at the time it appeared that this gas had been used in an Otto engine at the rate of thirty-five cubic feet per hour for each horse-power. As the gas was produced at the rate of about twenty-seven cubic feet per pound of coal, it is easily seen that the engine was running on an equivalent of a little less that one and one-third pounds of coal per horse-power per hour. At the common retail price, the gas was worth fifty cents per 1000 cubic feet and there was every reason to suppose that the price could be reduced by a large per-

centage in the case of a larger plant. Ample evidence was given, however, to show that with the plant in question a great saving over coal was effected, even

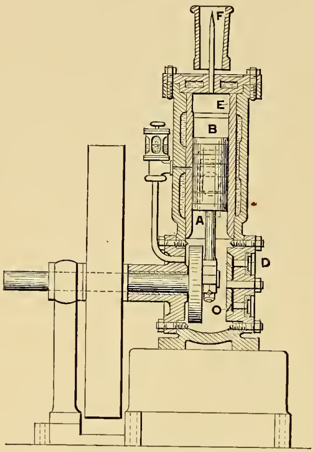


FIG. 9—THE DAY GAS ENGINE. FRONT SECTIONAL ELEVATION.

though it did not produce the gas at the lowest possible rate.

In several other cases in England where Otto gas engines were supplied with cheap Dowson gas from Dowson producers specially erected for the purpose, it was found on test that the engines consumed on an average the equivalent of 1.2 pounds of coal per indicated horse-power per hour. These results at the time had not a little to do with the subsequent building in England of gas engines of comparatively high powers,—double-cylinder engines indicating in the neighborhood of seventy horse-power.

As to the possibilities of the uses of gas and its future as a source of power, it may not be amiss here to refer finally to one of C. William Siemens' addresses to the British Association for the Advancement of Science in which he expressed the conclusion that if a temperature of about 2732 degrees Fahrenheit and a pressure of four atmospheres could be obtained in an explosive gas engine, a theoretical efficiency of about one-half could be obtained, while with a good expansive steam engine the theoretical efficiency would be about two-sevenths. Deducting the losses by friction and by radiation in both kinds of engine, he held that the best steam engine would yield in mechanical effect about one-seventh of the heat energy, while with the gas engine one-fourth could be easily obtained. As a prediction he finally remarked that "before many years we shall find, both in factories and on board ships, engines with a fuel consumption not to exceed one pound of coal per effective horse-power per hour, and with these engines the gas producer will take the place of the steam boiler." This prediction, made a little more than ten years ago, has, as we all know, scarcely yet been fully realized though much progress has been made in the direction outlined,—how much, it is, in a measure, our

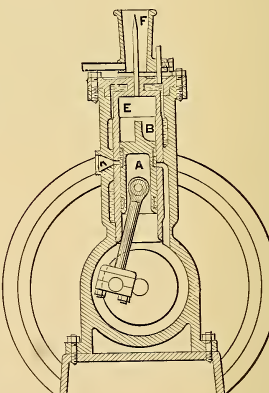


FIG. 10.—THE DAY GAS ENGINE. SIDE SECTIONAL ELEVATION.

object to show here by an exposition of the various gas and oil engines now in current use, doing a large variety of work.

THE OTTO GAS ENGINE.

It seems but rational and proper that we should begin our series of descriptions with an account of the Otto engine, or Otto "Silent" engine as it was called in its earlier days, since Mr. Otto, the first to succeed with the free-piston engine, was also the first to succeed in adapting compression in a reliable form, and since, further, it is to the utilization of this compression principle that the gas engine owes its present advanced state of development. The Otto engine belongs to the third type previously referred to, using a gaseous explosive mixture, compressed before ignition, and ignited in a body, so that the pressure increases while the volume remains constant. The power is obtained by expansion after the increase of pressure. It is interesting to note that the Lenoir and the Hugon engines were practically double-acting, there being two explosions for every revolution ; the Brayton engine is single-acting, there being one ignition of a charge for every revolution ; the Otto engine, however, is what may be termed only half single-acting, there being one explosion for every two revolutions of the engine.

The first of several designs of the engine, and one which is still looked upon as the standard form, has a single horizontal, open-ended cylinder. In this works a long trunk piston the front end of which serves as a guide. The cylinder is appreciably longer than the piston stroke, so that the piston, when full in, leaves a considerable space at the end of the cylinder into which it does not enter and which forms a compression chamber. Across the back end of the cylinder works a slide valve, controlling the admission and explosion of the charge, and held in place by a cover plate and strong, spiral springs. The valve is worked back and forth by a small crank on the end of a shaft parallel to the cylinder axis, and rotating at half the speed of the main crank shaft from which it receives its motion by bevel gearing. An exhaust valve and governing gear are also worked from this secondary shaft.

The engine cylinder serves alternately the purposes of motor and pump. During the first forward stroke of the piston, the admission valve is in such position that the gas and air mixture streams into the cylinder from the beginning to the end of the stroke ; the return stroke then compresses the mixture into the space at the back end of the cylinder. Meantime the slide valve has moved to another position, first closing the admission port to permit the compression of the charge, and then exposing a cavity in the valve in which there is a gas flame when the compression stroke is completed. The compressed charge is then ignited and under the influence of the resulting explosion the piston again moves forward. This constitutes the motive stroke. At the end of it the exhaust valve opens, and the return stroke drives out the burnt gases. The piston is then again in the position to take in a new charge for the next explosion. The cylinder is water jacketed.

A sectional plan of the original Otto engine is given in Fig. 1. In this A is the cylinder ; B, the piston ; C, the compression chamber ; the admission port shown extending through the cylinder head communicates alternately with the gas and air admission port E, and the flame port F, both of which are in the slide valve G. The latter, as already explained, is held in place by the cover J in which is carried the igniting jet R. The exhaust valve, which is a lift valve with a conical seat, is at K and is driven by the geared shaft M through a cam and lever, N and P. The main slide valve is also driven from this shaft in the manner clearly shown in the illustration. The governor with which the engine is provided is so arranged that when the speed goes above the normal rate it acts on a cam controlling the main gas supply valve and prevents its opening when the piston is drawing in air. To start the engine the igniting jet at R should be lighted, the gas supply turned on, and a few turns be given to the fly-wheel by hand. In some of the later types of Otto engine the admission slide valve G is replaced by a poppet valve design,

Fig. 2 showing one of the modern styles of larger size, indicating about sixty-five horse-power. In this later design, the igniting jet used in the earlier form of engine for exploding the gas charge has also given way to what is known as a tube igniter, or hot tube. This, as its name implies, is simply a wrought iron tube of small diameter, closed at one end. The open end is made to communicate with the engine cylinder by the valve arrangement. The tube is heated by a Bunsen gas flame within a non-conducting casing to prevent loss of heat, and the explosive gas mixture from the cylinder, entering the heated tube under pressure, becomes ignited. This method of ignition is at once simple and effective. The tube, moreover, is inexpensive and can be easily renewed when necessary.

The almost infinite variety of uses to which the engine may be put, and for some of which special designs are turned out, will not admit detailing here and we must content ourselves with the few examples shown. Thus, Fig. 3 shows a modern Otto engine applied to electric lighting, the sizes for this work ranging from fifty to 100 horse-power. Fig. 4 shows an engine and pump combination of the latest design in which gear wheels for driving the pump, as first used, have been entirely displaced by belting and correspondingly quiet running has been secured. Double-cylinder and vertical Otto engines are also on the market, all having their legitimate field of use.

THE OTTO GASOLINE ENGINE.

The poppet valve design has been adopted also in the Otto gasoline engine which has been on the market only a few years. This engine, like all oil engines, can be used where gas is not available, an advantage which has much to commend it and which in a measure explains the impulse which has been given to the oil engine industry during the past few years. In appearance and action the Otto gasoline engine is practically similar to the Otto gas engine, embodying as it does, only some minor valve modifications, and Fig. 2 may, therefore, be taken to represent it as well as its gas ally.

In this engine the gasoline is supplied from a tank which may be located outside the building, through a galvanized iron pipe with soldered joints, and provisions are made against any possible leak of the oil between engine and tank, or after it has reached the engine. The gasoline flows to the admission valve on the engine cylinder by gravity, and on being atomized or sprayed within the cylinder by a current of air, is at once fired either by an electric spark or by a tube igniter. Safety considerations may make the electric ignition method the preferable one, and this is therefore generally used.

While the gasoline engine can be used everywhere, and is not limited to exclusive use outside of cities because of possible gasoline vapor dangers, still the largest number of these engines have been placed in manufacturing suburbs not reached by city gas, and in the country. Like the gas engines, they are turned out in various designs for various kinds of work, and gasoline mining engines, electric light engines, portable engines mounted on trucks, etc., are now not uncommon.

Messrs. Schleicher, Schumm & Co., of Philadelphia, Pa., are the builders of both the Otto gas and the gasoline engines in the United States, the sizes of both types ranging from one-third horse-power upward. In England the Otto engine is made by Messrs. Crossley Bros., of Manchester, to whose design reference will be made in a future issue.

THE FIELDING GAS ENGINE.

The Fielding engine is made by an English firm, Messrs. Fielding & Platt, of Gloucester, the accompanying illustrations, Figs. 5, 6 and 7, showing one recently built and capable of indicating 100 horse-power at a speed of 160 revolutions per minute. The engine works upon what has become generally known as the Otto cycle referred to in the just-given description of the Otto engine as well as somewhat earlier in this article; but the arrangement of the valve gear embodies some new features. Fig. 5

gives a general view of the engine, while Figs. 6 and 7 show an elevation and a plan respectively.

The working charge is admitted and the waste products exhausted by means of a simple mitre-seated valve, through inlet and outlet ports controlled by the movements of a piston valve which receives independent motion from an eccentric, which also operates the timed ignition valve. The valves are placed horizontally by the side of the cylinder, an arrangement which permits of very straight and direct pipe connections for gas and exhaust, the air being drawn through the cylinder base, which acts as a muffle. The main mitre-valve is worked from a cam by a rod leading direct to the valve. The governor is of the high-speed, ball type acting upon a hit-and-miss gear interposed between the gas valve and its cam.

The importance of a starting gear for engines of such large size which cannot easily be turned over by hand is at once apparent, and due account has been taken of it in this engine by the provision of a new form of such gear patented by Mr. Fielding. This gear comprises a small reservoir of about the size of the cylinder jacket, which, after the engine has once been started, is charged with compressed air at a pressure of about fifty pounds per square inch by the engine itself when being stopped, thus utilizing the power stored up in the fly-wheels for use when re-starting the engine. The action of starting is as follows : The engine crank being placed slightly in advance of the dead centre nearest to the cylinder, gas is admitted by a small cock to the combustion chamber, from which the air is allowed to escape at a small pipe provided with

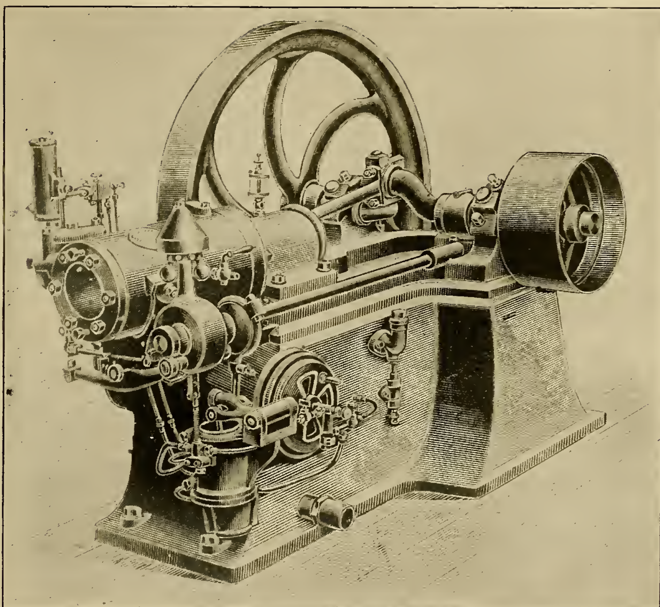


FIG. II.—THE GRIFFIN OIL ENGINE, CONSTRUCTED BY MESSRS. GRIFFIN & CO., BATH, ENGLAND.

a stop-cock and terminating in a jet near the top of the tube igniter.

When the air has been driven out and the gas begins to escape at the jet, it becomes ignited, and as soon as it burns with a steady flame, showing that an ample supply of gas is present in the cylinder, the outlet and inlet cocks are closed. Compressed air is then turned into the cylinder, and the igniting valve being open, as soon as an explosive mixture is formed and sufficient pressure attained, the charge is ignited by the igniting tube, and the piston is driven forward with a powerful impulse, the ordinary cycle at once coming into operation. This method of starting is claimed by the builders to be so powerful that an engine can be started with partial load on, and any arrangement of fast and loose pulleys or friction clutch is thus entirely dispensed with.

THE DAY ENGINE.

The Day engine, shown in perspective and sectional elevations in Figs. 8, 9 and 10, is built by Messrs. Llewellin & James, of Bristol, England, and appears to have been designed with special reference to adaptability to domestic or other uses where the utmost simplicity and consequent ease of management by unskilled attendants are primary considerations. Few moving parts and an entire absence of what may properly be considered valve gearing are therefore the leading features of this engine. What moving parts there are besides the piston and fly-wheel are, moreover, completely hidden by a casing, so that the engine is simple in appearance as well as in fact. The crank chamber, as shown, is closed in and as the piston A rises a partial vacuum is formed underneath, and gas and air in proper proportion are drawn in through the passages D. These are controlled by a flap valve on the inside of the crank casing, and when the piston, after having reached the upper end of its stroke, begins to descend, this flap valve closes the gas and air inlets, and the completion of the down-stroke causes a slight compression of the explosive mixture in the crank chamber. At the end of the down-stroke a port opening at the side of the cylinder is uncovered by the upper end of the piston and through this the explosive mixture rushes into the cylinder proper above. In passing into the cylinder the gases impinge on the fin B on top of the piston and are thus deflected upward, displacing the products of combustion of the previously exploded charge, which pass out through the exhaust opening K (Fig. 10). The cylinder now is practically filled with an explosive mixture at atmospheric pressure. The piston, now again rising, cuts off both the supply and exhaust openings, and the mixture in the cylinder is compressed. When the piston reaches the upper end of its stroke, it drives the gas mixture into an ignition tube, F, and an explosion results.

It will be understood from this that there is one explosion for every double stroke or every revolution. A water-jacket keeps the cylinder cool. To start the engine, which obviously is made only in small sizes, it is simply necessary to give a few turns to the fly-wheel by hand.

THE GRIFFIN OIL ENGINE.

The Griffin oil engine, made by Messrs. Griffin & Co., of Bath, England, works with ordinary petroleum, either such as is used in domestic lamps, or with the cheaper and heavier varieties. This engine, too, works on the four-stroke or Otto cycle.

The points of novelty lie principally in the vaporizer, and in the burner for keeping the incandescent firing tube red hot. The vaporizer lies athwart the bed under the cylinder. It is a cast-iron vessel, surrounded with a passage for the emission of hot exhaust products from the cylinder, and provided internally with ribs to increase the heating surface. The oil enters it at one end, that shown in Fig. 11, in the form of fine spray, and is drawn out through the curved neck at the opposite end, Fig. 12, into the cylinder. In their passage the vesicles of oil become converted into vapor by the

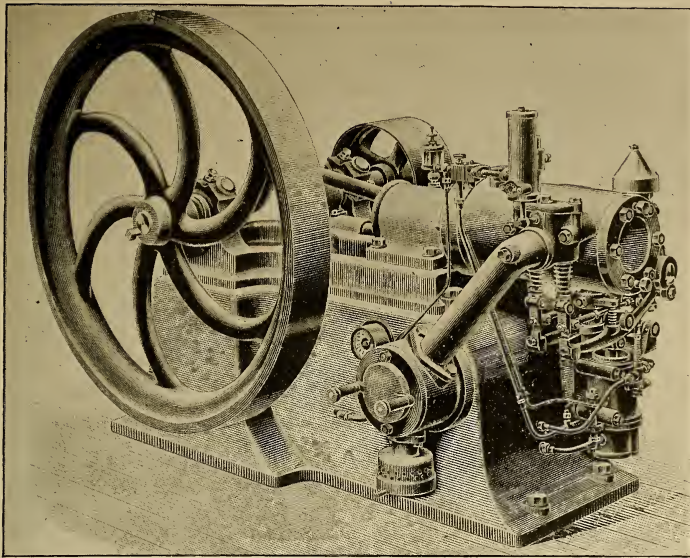


FIG. 12.—THE GRIFFIN OIL ENGINE.

heat of the walls, and shortly before the cylinder is reached they are mixed with additional air entering through the box to be seen below the bed. This air also has its temperature somewhat raised, as the inlet and exhaust passages run side by side in the curved end of the vaporizer leading to the cylinder. The spraying of the oil is effected by air compressed to twelve pounds on the square inch by a pump worked off the side shaft. The oil runs by gravity out of a reservoir in the bed, and is emitted through a fine tube into the air delivery nozzle. The blast picks it up, and, driving it forward, atomizes it at once. The flow of oil is regulated by the air jet itself; when the jet is cut off by the governor, the oil ceases to flow. This result is attained by means of a valve on the oil pipe. This valve closes naturally and is only opened by the air pressure; immediately this is admitted to the pipe the valve lifts and the air flows.

The heating of the incandescent tube is accomplished simply and ingeniously. The oil trickles into a tiny box and flows over a weir, which keeps it at a constant height. Two little wire pins stand in the oil at such a distance apart that the liquid creeps up between them by capillary attraction. On to the head of the column so raised, there impinges a fine air blast, which sprays the oil and carries it forward through a pipe to a Bunsen burner playing on the ignition tube. The pipe rapidly becomes heated by conduction from the burner and effects the vaporization of the oil, which burns like a gas jet, without odor.

The governor is of the centrifugal type and controls a hit-and-miss device. From this there is worked the admission valve, the exhaust valve, and the air inlet to the vaporizer, all being thrown in and out of action simultaneously. It is claimed as a feature of importance in the engine that all the valves are at rest when running light and operate only in direct proportion

to the work being done, thus saving wear and tear.

The vaporizer needs to be heated before the engine is started. A hand lever is supplied by which the air-pump is worked for ten minutes. The air is used to spray the oil, as if the engine were at work, but the jet is ignited as it enters the vaporizer and fills the latter with a powerful flame. A door is opened at the further end of the vaporizer and a temporary deflector fixed on to direct the flame under the passage leading to the cylinder. Ten minutes suffice to raise the temperature to the required extent. Up to the present time only small sizes of the engine have been built, but larger designs are under way.

(*To be continued.*)

THE UNITED STATES PATENT OFFICE.

By R. D. O. Smith.

I HAVE just read with interest Mr. Leon Mead's "Influence of Patents on American Industries," and regret that his examination should have been so brief. The cornerstone of our national prosperity is worthy of more exhaustive treatment.

In his first paper there are one or two errors which, while not momentous, still ought to be corrected. On page 117 he says: In the year 1812 the Patent Office was removed to a building purchased and repaired for the accommodation of the general post-office, and that said building stood on the site of the present post-office department building. Washington was captured by the British in 1814, consequently the episode and removal mentioned are placed at a date too early.

The building to which the Patent Office was removed was located where the so-called city hall now stands in Judiciary Square and not on the site of the present general post-office. When I went first to Washington in 1857 the city post-office was in a rickety old building on Seventh street, on ground now occupied by the general post-office. It had been standing there many more than twenty years.

There was saved from the fire of 1836 out of the records of the Patent Office but a single drawing. Patentees were invited to return their letters patent to the commissioner, who had the specifications copied into books and the drawings copied on sheets for the draftsman's room. Many of these reproduced drawings are models of artistic excellence.

But many patentees neglected to have their patents re-recorded. In fact, I presume but few except those whose patents were still young, or which had proved to be remunerative, responded. A great many who did respond also filed duplicate models.

At the fire of 1877 but few, if any, models of pending cases were lost, since models of pending cases are kept in the secret archives of the office, and mostly in the examiner's rooms. The fire did not extend beyond the north and west model rooms on the upper floor. None of the examiners had rooms on that floor at that time, and few, if any, of the paper records were lost. I believe there were some duplicate copies of the printed specifications which were burned, but none of the original records and none of the relics or other mementoes which were then preserved in the Patent Office, since all such were kept in the old or South Hall. The two burned model halls were the most spacious, and contained, I presume,

more than half the models on file, but the whole number was considerably less than 200,000. I estimated about 75,000 models in the two halls, and strange as it may seem, a considerable number of these were not materially injured, while about 20,000 were not injured beyond recognition and further usefulness.

I regret that Mr. Mead's glowing tribute to the value of a collection unequaled in the world, a collection where "students of mechanics and of the industrial arts from all over the globe found untold volumes of enlightenment," should not have been followed by some consideration of the acumen of a commissioner who relegated these volumes to back shelves, and by the simple act of writing his name made back numbers of them, because he feared that in a little while the city of Washington could not accommodate a collection so vast as it would become. Students from anywhere no longer visit those halls which for all time ought to be classic. The glorious collection of American inventions is now fifteen years behind date. And in the United States fifteen years marks time for several industrial revolutions. There is scarcely a fifteen-year-old machine in our workshops which can to-day hold its own in competition with present practice. Why then should students visit these halls unless in search of ancient history? Of so little interest are they now that classic South Hall has been reconstructed for the purpose of furnishing entirely inadequate accommodations for the library. The East Hall has almost entirely been remodeled to furnish additional rooms for examiners and the West Hall is given over to storage of duplicate copies of specifications.

It is shame to the American people that the source of her golden eggs should be so treated. The inventors of the United States yearly contribute more than $100,000 to the useless patent fund, which now amounts to about $4,000,000, idle in the vaults of the Treasury—dedicated to the use of the Patent Office—and unusable for any other purpose, but useless for that, because the Congress of the people year after year simply refuses to give the matter any attention,

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A NEW ETHER ENGINE.

According to a recent issue of a foreign technical periodical, an engineer in Paris claims to have perfected and made commercially practicable, an engine for using a liquid—such as ether—boiling at a low temperature, and he believes, with the characteristic confidence of an inventor, that this must lead to a complete revolution in the construction of the marine engine at least. The ether is vaporized and condensed repeatedly without loss. Such an engine offers the advantages of lightening boats and locomotives by making the load of water for the boilers unnecessary, and of avoiding the risk that arises from boiler incrustation. Another advantage in many cases, such as that of war vessels required to start at short notice, is the quickness with which pressure may be obtained, and the machinery put in motion. The ordinary economy of the ether engine has not been determined, but it has been employed in connection with a steam engine, and, by using the heat of the waste steam, has given a considerable increase of power without additional fuel. From many experiments made in America as well as abroad by able engineers, very little encouragement for the use of ether has been obtained, and it is more than likely this latest idea will meet the fate of its predecessors.

A NEW METHOD OF STORING POWER.*

By Prof. George Forbes.

WHEN asked to write a paper on some electric lighting subject, it seemed to me I could not choose a better one than thermal storage for central stations, which had so much attention directed to it lately in England. It has long been evident that storage of some kind might lead to great economy in central station work. The reason of this is that the demand for electric light has in most cities a maximum for only two or three hours of the day. Not only do we require to have the plant lying idle all the rest of the day, but the expense of working for these few hours is increased by its temporary character. This loss of economy has occurred both in engines and boilers. Underloaded engines are very inefficient and use up a lot of coal. This effect is, however, gotten over in all important central stations by having at least a few engines of small power to carry the day load. We are thus able to have engines in use always working at their most economical load—that is, near full load. The other loss in economy comes from the boilers, which have to be fired up and heated for only a few hours' work and then banked or else allowed to cool down. This loss cannot be overcome by working the ordinary plant in any special manner. At the Kensington station, London, where the engines are always working at an economical load, five pounds of coal are used per electrical horse-power per hour, whereas in tests of twenty-six hours' duration, made on the same plant with all the boilers doing full work, only three and a half pounds of coal were required for the same duty. If, then, we could have storage of any kind by which power is absorbed at times of light load and given off at times of heavy load, we should save one and a half pounds of coal per horse-power per hour. Many people have thought that storage batteries would overcome the trouble. It does so, but at an enormous capital expenditure for storage batteries, with a loss of twenty per cent. in the energy given to the batteries, and with a depreciation account which no one would put at a less figure than twelve per cent. per annum.

I have previously proposed that in a hilly country the boilers and engines should be working all the twenty-four hours, at the rate of the average demand, and that they should be used to pump water through a pipe to a high reservoir at least 500 feet above the pumping station. At the lower end of the pipe turbines are placed driving dynamos. During day time the reservoir is being filled and in the evening it is being emptied. This produces a saving in boilers and the substitution of cheap turbines and a small number of efficient pumping engines for a large number of less efficient engines to drive dynamos. It also reduces the coal consumption from five pounds to three pounds per horse-power per hour. In a paper read last year before the British Association for the Advancement of Science, I showed that this plan could easily be adopted in Edinburgh, in Scotland, the saving in capital and annual expenses being both very large. But it is not every city that has these advantages, and I wish now to introduce to your notice the excellent scheme which has been invented by Druitt Halpin of Edinburgh.

He proposes to put up boilers only of the average capacity and to work them day and night. At times of light load the steam is carried through pipes

* Read before the National Electric Light Association, St. Louis, March 1, 1893.

into large iron reservoirs of cheap construction, and is used to heat the water in these reservoirs to a high temperature and pressure. When the heavy demand comes on in the evening, steam is drawn from these reservoirs. The losses of heat from radiation from the reservoirs can be made very small, indeed, with proper lagging; in fact, quite imperceptible.

This is the general scheme of Mr. Halpin's plan. But it has two advantages which are not so apparent at first sight. One is the purity of the water supplied to the boilers. Mr. Halpin's pumps feed water into the hot reservoirs when impurities are precipitated in a place where they can do no harm. The boilers, on the other hand, are fed from this pure water in the reservoir.

The other incidental advantage of the system is that priming the boilers does not cause any inconveniences, as the steam is supplied to the engines from the reservoirs. Now, it has been found from the experience with the water tube boilers which are so much used in this country that only three pounds of coal per hour can be burned per square foot of heating surface, on account of the excessive priming, instead of the six pounds per square foot which we can use with the Cornish or Lancashire boilers, and which might be used with water tube boilers if priming were no objection. Thus it appears that the adoption of Mr. Halpin's system not only reduces the number of boilers that we require, but also doubles the capacity of each boiler.

Mr. Halpin has worked out the relative cost of supplying machinery to the central station of Berlin (1) without any storage, (2) with storage batteries and (3) with thermal storage. He first selected this station because the output at each hour of the day all through the year was published before any other central station had published similar data. In this system there are four central stations, giving off about 10,000 electrical horse-power.

The load at different times of the day is such as to lead to the following data:

Maximum load	7,500 kilowatts.
Mean load	2,030 "
Excess of max. above mean	5,080 "
Duration of ditto	7.5 hours.

Now, Mr. Halpin claims that he can replace twenty-two boilers for working in the ordinary way by five boilers and ninety-two of his storage cylinders, which are cheap to construct and have necessarily a small evaporation. His claim, which I must admit seems to be quite well founded, is that while laying out somewhat more capital on his plan, he gets a very large return for the extra capital spent. He sums up the cost of the thermal storage system as follows:

Five Babcock & Wilcox boilers	$27,050
Boiler house	9,500
Chimney	4,500
Cylinder house	33,300
92 cylinders	184,000
Total	$258,700

And he puts the cost under the existing system at $182,700.00.

Now, if we charge ten per cent. to annual depreciation of boilers and only five per cent. on iron cylinders, which really seems a very fair value, then the annual interest and depreciation comes out almost the same for both systems, thus:

EXISTING SYSTEM.

5 % on $182,700 capital	$9,135
10 % on $117,850, boilers	11,785
4 % on $64,850, buildings	2,600
Total	$23,520

THERMAL STORAGE.

5 % on $258,700 capital	$12,935
10 % on $27,050, boilers	2,705
4 % on $47,050, buildings	1,900
5 % on $184,000, cylinders	9,200
Total	$26,740

The annual charges against thermal storage are $3220, but the annual saving in coal is, in this special case, 7000 tons, besides the saving in ash removals and firing. Mr. Halpin thus obtains figures, giving an annual saving of $36,530 to pay interest on extra capital of $75,000, with coal about $5 per ton.

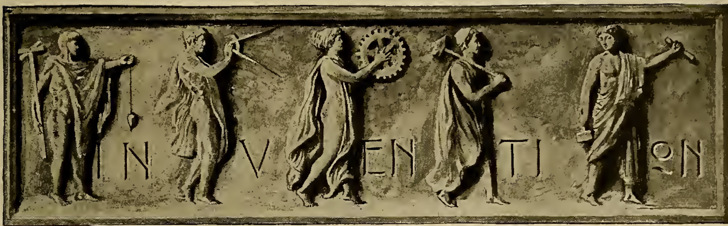
Now, the only kind of storage against which Mr. Halpin has to com-

pete, when high land is not available for utilizing water storage, is the storage battery; and from his figures, which seem fair to me, the extra capital required is $732,200, and the total annual extra cost, $110,750, which shows a great advantage in thermal storage.

I consider that all these figures are very conservative, and that in these days when we are learning to realize the importance of cutting down working expenses in central stations, this system must necessarily occupy an important place. But it is of peculiar interest to me, owing to its applicability to a kind of work to which I have devoted a large part of my time in the last seven or eight years. I refer to the burning of the house refuse and garbage in our cities. The furnaces in which this cremation is accomplished are generally call "destructors." It has been one of the great objects before me of late years to have this title abolished and to justify their being called "utilizers." The improvements which we have introduced in the methods of burning refuse are so great that I can now undertake to produce the following results:

Taking the ordinary house refuse, ashes, coal, wood, paper, old books, vegetables, bones and scraps, crockery, tin cans, iron pots, bottles, and adding thereto occasionally dead cats and dogs, infected mattresses and condemned meat, I can throw the whole of these, without sorting, into the furnace, and without producing any offensive odors or dust I can raise the temperature of the gases where they reach the boilers to over 2000 Fahrenheit. From my data as to the amount collected in different houses in England per head of the population, I find that from the house refuse of any town I can supply steam enough to generate electric light at the rate of one sixteen candle-power lamp per head of the population for two hours every night of the year. By doing this I am saving the municipality from $10,000 to $20,000 per annum per 100,000 inhabitants for the cost of the removal of house refuse. I am preventing these objectionable materials from being dumped into the outskirts of the city, where building operations will soon commence, or in the neighboring harbors or lakes, either of which plan is a nuisance and unhealthful. The only resulting material is a clinker, which can be broken up, and which when mixed with cement makes admirable concrete or artificial stone for paving, while by itself it makes excellent foundation for roads.

Now these enormous advantages, of the truth of which we have ample proof from a practice extending over nearly twenty years in England, can be worked at full economy only when the burning of refuse is quite continuous and uniform. To do this we must have storage of some kind. In hilly countries the plan I have advocated of water storage is generally available, and is very economical. In all other cases thermal storage is far and away the most economical mode of working, and in this line alone, if in no other, I have always said, from the first moment I knew of Mr. Halpin's invention, that we have here the last item which was wanting in order to do away with the barbarous methods generally adopted for getting rid of house refuse, and at the same time utilizing that refuse in a manner that will confer material benefits on all the inhabitants of a great town, and pecuniary advantage on those who undertake the work.



NOTES ON NEW AND PATENTED INVENTIONS.—VI.

By John Richards, M. E., Editor of "Industry."

IN the February issue, under the head of Shaft Couplings, muff, flange and compound couplings were illustrated. Coming now to interchangeable couplings, all of which belong in a class that may be called compression, that is, capable of being clamped on the shafts to secure a fit, and be loosened by means of screws, wedges or other devices. Such couplings we will speak of under the general head of compression ones, and give some examples to show the various expedients that have been adopted to clamp them on the shafts.

Compression couplings, while they seem to be divided into two classes: one with conical collars, tapering wedges or screws that act indirectly, and the other class, plain clamps that act directly by means of bolts or screws. If examined, however, it will be seen that in all couplings of either kind the method of compression is based upon flexure. There is, indeed, no means of reducing the bore of a coupling, or anything else made of iron, except by either flexure or condensation of the material.

This may seem a bold proposition in view of the fact that not only in couplings but in many other cases, such as compensating bearings for shafts or spindles, we find devices for concentrically reducing the bore of holes, but if any or all of these contrivances are analyzed it will be found that no such reduction of bore can take place without flexure, and in the case of conical collars without the metal being condensed or "upset."

Another principle involved in all adjusting conical devices, is that adjustment in the plane of the bearing or running faces can do no good, in other words, adjustment parallel to any face causes no change normal to that face. It is true that many such adjustments are provided for clamping and for compensation in bearings, and seem to answer such a purpose, but this claim is only a compliment to good fitting, the fact being that adjustment is not required. This is certainly the case with the spindles of machine tools, because any attempt to adjust a conical bush diagonal to its exterior face must lead to distortion, and a bad fit that would show itself in milling machines and lathes where such bearings are usually found.

In considering this subject of compressing or clamping devices by means of tapers or cones, it is important for those who have not previously examined the subject that this matter of adjustment should be made plain before

referring to the particular devices. Figs. 5 and 6 are prepared for such explanation. Suppose that *B* and *B* are conical bushes, one tapered on the inside as in Fig. 5, the other tapered on the outside as in Fig. 6, and that the adjustment in Fig. 5 is on the line *n*, and in Fig. 6 on the line *m*.

The construction in Fig. 5 is common in various kinds of machinery in Europe, and to some extent employed in this country for lathe spindles and the like. That in Fig. 6 is common in this country, but, so far as known, is not employed elsewhere. The two things seem analogous at first sight, but they are not so. Adjustment in Fig. 5 is on the line *n*, diagonal to the running faces, consequently these approach or leave each other parallel as the bush *B* is moved backward or forward in the stationary part *A*, forming a complete annular adjustment.

In Fig. 6 adjustment is also on the line *n* the same as before, but is parallel to the shaft and the running faces, consequently can have no effect on these faces without condensing or compressing the bush itself. It will also be seen that as this adjustment is diagonal to the outer faces of the bush on the line *m*, consequently it is not possible, because movement endwise cannot take place, unless, as before remarked, the bush is condensed.

If the bush is split it may be closed in a slight degree, but not concentrically, because there is no fit except in one position. It is bad construction in any case, when directed to a reduction of bore, unless the bush is made of some soft alloy that can be compressed so as to change its shape. We have treated this matter at some length, because it is a method common in compression couplings, and its limitations not well understood. It is not contended that there is no compensation or adjustment of such devices, but that it is infinitesimal without destroying the fit.

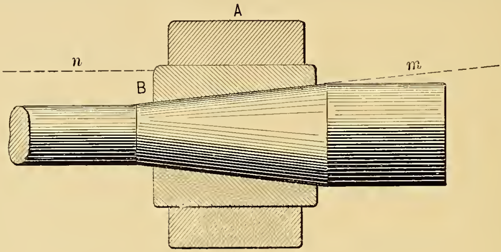


FIG. 5.

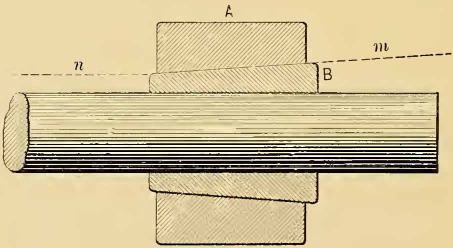


FIG. 6.

There is, in some cases, a successful application of this conical bush method of clamping by cutting away the exterior of the cone so it will bear on narrow faces only, as in Figs. 7 and 8, taken from a clamping spindle chuck made by a firm of machine-tool makers at Manchester, England.

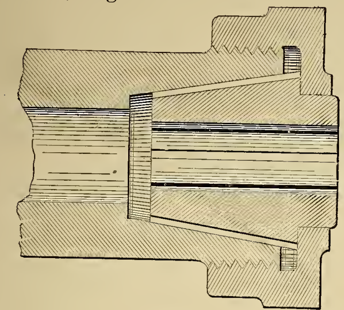


FIG. 7.

Fig. 7 is a longitudinal section and Fig. 8 an end view with the screw collar removed. The conical member is split into six parts, and the exterior cut away so the bearing is on twelve narrow ledges that by reason of the small area in contact can be adjusted in the socket.

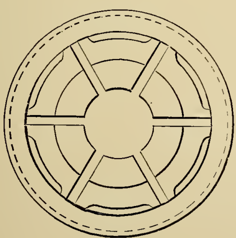


FIG. 8.

The drawing is made from memory, and may not be correct in all respects.

Another example of successful clamping in the same manner is shown in Figs. 9 and 10.

Fig. 9 is a section through a shaft coupling designed by the writer in 1885. Fig. 10 is an end view of one of the cones. The drawing is taken from a coupling of two and one-half inch bore, and the bearing ledges on the cone were about three-eighth inches wide, eleven in number, the cone being slit through at one point and partially cut through at three other points, as shown in Fig. 10. This, as will be seen, is the same thing as the chuck just described, and

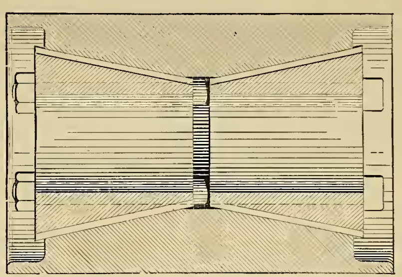


FIG. 9.

the range of compression, without distortion or bad running, was a good deal increased over cones that had a bearing all over their outer surface.

The limit in this direction, however, was not in the exterior of the cone, but the interior bearing on the shaft. If the cone had been split into four parts it would have closed on the shaft at four

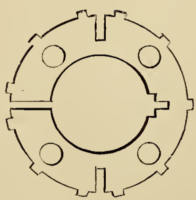


FIG. 10.

or eight bearing points as the fit was close or loose, but as made, the fit on the shaft was defective when the size of the latter was varied from the standard size for which the couplings were bored.

The coupling shown in Fig. 11 was also designed by the writer in 1866, at a time this subject of cone adjustment

came up as a problem in the works. The theory was, that a thin shell or sleeve around the shaft when split open on one side would close concentrically, and fit on shafts that varied so much as is common in turning and finishing them. The drawing is from a coupling

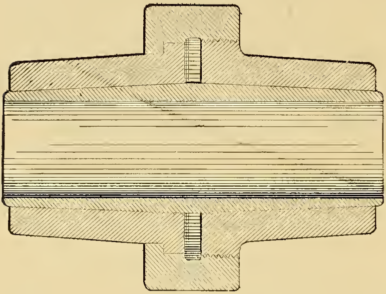


FIG. 11.

of two and one-half inch bore, the sleeve being three-sixteenth inches thick at the ends, and seven-sixteenth inches at the middle.

The conjecture respecting concentric action of the shell was correct for a limited amount of adjustment, but, as in all cases of screw and wedge action, the friction of the screw collar prevented the couplings being drawn up with a common spanner, but by driving on the outer shells with a maul or hammer the couplings could be made so fast that no keys were required in ordinary use.

These couplings were made both in this country and Europe. Perhaps, as yet, their history is not known, but the accuracy of the work required in making them has, no doubt, prevented successful competition with cheaper modifications.

Fig. 12 represents a coupling the name of which cannot now be recalled. It is included here to explain some features of design peculiar to all mechanism for "connecting" as well as shaft couplings.

It was pointed out at the beginning that the functions of a coupling were to impart a rigidity equal to that of the shafts connected, and to transmit torsional strain equal to the strength of the shafts. To these can be added another rule, that the compression or gripping strain should be enough to prevent movement in the sockets or bore, and a third rule, that all these three functions should be performed by the same members, that is the same metal employed to secure rigidity should perform the office of compression, otherwise the size and weight of a coupling will be increased in proportion as these functions are independently performed.

Fig. 12 is introduced to illustrate this matter. The transverse strength of the coupling, or its rigidity, is represented in this case by the cross section of the inner shell or sleeve at the middle, where the coupling is nearly cut in two. It will also be seen that the function of compression or fit is performed by the inner pair of rings or collars, and that these have no other office; also that the ring nuts at the end have no function except to press the inner rings on the conical faces of the sleeve.

Applying the rules before named, their truth will be apparent in dimensions of this coupling. It is a cylinder having a diameter at least three times that of the coupled shaft, if made of cast-iron, and its weight double that of any

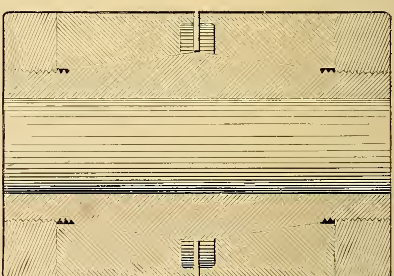


FIG. 12.

coupling in which rigidity, compression and torsion are all provided for in the same members.

Very good couplings of minimum weight have been made on the same principle as shown in Fig. 13, where

the member in compression *e* is of cast-iron, and the members in tension *a a*, are of wrought-iron. The main shell *e* is in two parts, and the rings *a a* are driven on the tapering ends. Comparing, it will be seen that the two collars ous devices for compression, within solid shells that bear the reaction of the clamping force, are all amenable to the conditions pointed out, unless it be in the case of screws, which by reason of their helical exterior or bearing faces,

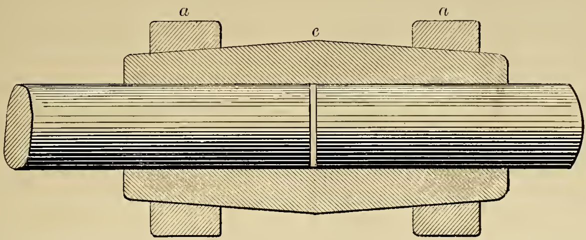


FIG. 13.

a a represent or perform the same functions as the four do in Fig. 12, and those in Fig. 13 being of wrought-iron, their section can be reduced to one-third or less than one pair of those in Fig. 12, or, in other words, the outer or enveloping members are, in practice, not more than one-sixth as heavy.

The couplings shown in Fig. 13, so far as we know, were first made by J. H. Cooper, of Philadelphia, and, aside from requiring to be driven on by blows, are among the best of their class. It is true the inner shell has to be heavy to furnish the required rigidity, consequently is not capable of much flexure, but the same remark applies to nearly all kinds of compression couplings, namely: they require that the coupled shafts be of accurate diameter in order to hold safely.

Almost any compıession coupling can be strained to clamp a shaft slightly under size, but the surfaces will not fit, and deflection of the shafts from the strain ot wheels or belts, or being out of line, will soon produce abrasive wear in the sockets, and failure. The fact is, that compression couplings to fit shafts that vary in size are a myth, except within very narrow limits not exceeding .005 of an inch. Of this, however, more will be said in the end.

Conical screws, wedges and the various devices for compression, within solid shells that bear the reaction of the clamping force, are all amenable to the conditions pointed out, unless it be in the case of screws, which by reason of their helical exterior or bearing faces, can be adjusted to a greater degree than the smooth faces of wedges or o nes.

Fig. 14 is a diagram, drawn from memory, of a compression coupling that has been extensively used, and seems to have filled the required conditions of such couplings very well. Compression is derived from flexure of the two members *e e*, these being forced in upon the shaft by two tapering screws *a a*, made with a fine thread and tapped into the slot as shown. The members

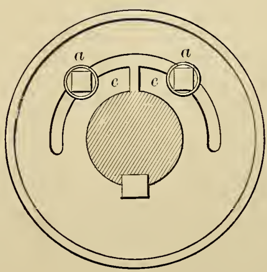


FIG. 14.

e e are severed at the middle of the coupling to permit independent action on each shaft. These close on the shaft in some degree concentrically, over one-half of the shaft's circumference, but it

is obvious that a fit is required, otherwise the coupling would soon wear out in the sockets if there is deflection of the shafts.

CLAMP COUPLINGS.

The class we have termed clamp couplings embraces quite a range of modifications, all practically the same in effect and nature, or nearly so, and are, no doubt, the best as well as the most simple that can be applied in an interchangeable system. As pointed out before, the function of closing or the reduction of bore in all devices of the kind is due to flexure, and in the clamping class of couplings the closing force not only performs the office of compression, but also produces, in a direct manner, the flexure required for closing or reducing the bore.

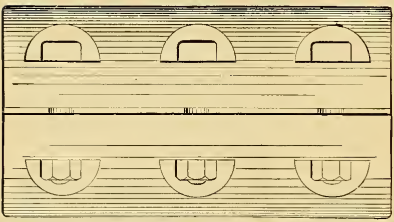


FIG. 15.

This can be illustrated by Figs. 15 and 16, which are side and end views of one of the oldest forms of clamp couplings. These were employed by Mr. Robert Briggs, of Philadelphia, a well known engineer, who died about twenty years ago. They can be seen in substantially the same form in the works of Cail & Co., Paris, the celebrated locomotive builders there. In this latter case they were made not less than thirty years ago, and most likely more than forty years ago, because in 1870 when we visited these works no one seemed to know how long it was since some of the older lines of shafting were connected in this manner.

These couplings are cheap, and when the shafts are carefully turned hold remarkably well, but it is obvious that if strained down upon shafts under size there is danger of fracture at the fulcrum of flexure opposite the slot. There is also the objection common to all couplings noticed this far, that they cannot be removed and replaced without taking

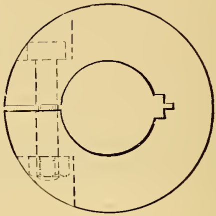


FIG. 16.

down or moving the shafts, and are not balanced in the distribution of the metal.

The exterior contour is free from projections that cause danger, but the clamping screws, countersunk as shown, cannot be turned with a common key, and require a socket one. These couplings have not survived, probably because their merits are not known, but more likely because they do not seem ingenious and complicated enough to meet common opinion.

Fig. 17 is an end view of the plainest form for clamp couplings, and the first modification among all the compression

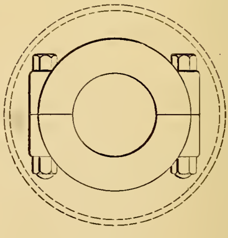


FIG. 17.

class this far referred to that can be removed and replaced without disturbing the shafts connected.

It will seem in controversion of history and common practice to claim that

a coupling of this kind, in addition to the advantage first pointed out, is the best that has been devised, and comes nearest fulfilling the desired functions for devices of the kind, but such a view

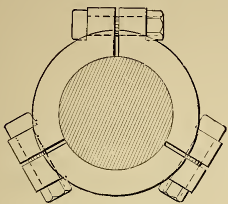


FIG. 18.

is in accordance with the facts. Clamp couplings were the first, and no doubt will be the last among devices of the kind.

The clamping bolts, in addition to expending their force directly in compressing, also tend as directly to bend the shell, and close it concentrically around the shafts, such action being perfect up to such limits as the metal will bear, and for any kind of malleable metal far beyond the irregularities of size that occur in fair turning.

One proof of the strength and reliability of couplings of the kind is that they are provided to connect broken propeller shafts at sea and successfully perform that purpose. A propeller shaft can be compared to an engine shaft from fifty to 150 feet long with a flywheel on the extreme end, and the enormous strains endured are indicated by the number of fractures that occur. The selection of plain clamps to connect broken shafts of the kind is strong evidence of strength, reliability and facility of application.

Such clamps when divided into three parts, as shown in Fig. 18, are still better, giving as we may say, nine points of impingement at the centre and each end of the arcs in contact. It would be an interesting and useful problem to resolve the compression strains in this case with certain assumed proportions. This will be done in a future place.

In some cases these clamp couplings have been housed or covered with a shell, as indicated by the dotted lines in Fig. 17. This, while it makes up a symmetrical device, is expensive, and moreover destroys one function, that of removal from the shafts in place, because the covering shell has to be made in one piece.

If a covering shell is made integrally with the main one, as in Figs. 19 and 20, the two shells being connected by flanges or diaphragms between the bolts, as shown in Fig. 20, there will be, with one exception, all the required functions that have been pointed out, with the least possible amount of metal.

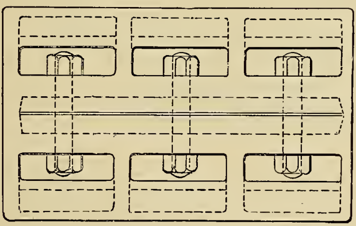


FIG. 19.

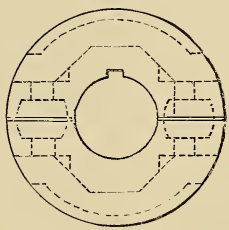


FIG. 20.

These functions we will repeat as follows: (1) to secure continued rigidity of the shafts through the coupled shafts; (2) to have a torsional resistance superior to the shafts connected; (3) a smooth contour to prevent danger of catching or winding belts or clothing; (4) to close for compression concentrically; (5) to be removable without taking the shaft down. To these conditions may be added some others of less importance, such as an avoidance

of jamming or rusting fast; admitting of the use of common wrenches to fasten or loosen the screws; the exterior adapted for use as a pulley for belts.

All these conditions are fulfilled by the clamp coupling shown in Figs. 19 and 20, except the clause No. 4 relating to flexure. A double shell, connected as shown, becomes very rigid, and the two halves close on the shafts as two semicircles. There is, however, flexure enough to meet ordinary requirements, because, in some experiments made in England in 1886, where examples of nearly all forms of compression couplings then known were tried, the present one showed the greatest truth and endurance when applied to shafts varying in diameter, and sprung out of truth until the couplings failed. Fig. 21 is a perspective view of one of these couplings as it appears when applied on a shaft.

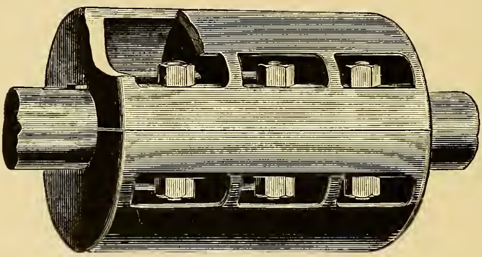


FIG. 21.

In this review of compression or interchangeable couplings, the purpose has been to select types and analyze the conditions or functions that pertain to them on commercial as well as mechanical grounds. Computations in respect to couplings, cover but a limited field, and are confined mainly to proportions for resisting torsional strain and flexure, but these are not in practice the principal facts to be dealt with. Failure comes in most cases from abrasion in the sockets or bearings for the shafts. A small amount of movement takes place because of a bad fit, or insufficient gripping power, and abrasion begins, ending with what is not inaptly called "chawing out the hole." The primary cause of failure is want of alignment, or flexure from other cause, such as the strain of belts or wheels that causes a slight movement in the sockets. Abrasion begins, and goes on in an increasing degree, until the end comes.

New inventions have not been reverted to or considered in this section on shaft couplings, because there has really been no recent progress in the art. The first interchangeable couplings made, the plain clamps, were among the best. Those with conical shells and bolts, invented and introduced by Messrs. William Sellers & Co., of Philadelphia, thirty or more years ago, and yet extensively made by this celebrated firm, are among the most complete that have ever been produced, and were the outcome of a successful attempt to reduce shaft fittings to an organized manufacture.

The principal difficulty met with in the system has been the mistaken opinion that such couplings were to fit on shafts varying in diameter, which, as at first stated, is a myth. Their object is to permit organized or duplicate manufacture of shaft fittings, and to facilitate putting on and removing the couplings from shafts. Without this there can be no systematic manufacture of the kind, and to compare interchangeable or compression couplings with keyed-on-flanges is to admit a lack of understanding the subject. There is a place for both methods, but not on line shafting as now produced and sold in this country.

THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Fifth Paper.

THE individual mistress of Edison's heart until now had been science, but a new potency was at hand, equally strong, but immeasurably more subtle and all-pervading. For

> "Love first learned in a lady's eyes,
> But with the motion of all elements
> Courses as swift as thought in every power,
> And gives to every power a double power
> Above their functions and their offices."

In the person of Miss Mary E. Stillwell, Edison again enjoyed the gentle and uplifting influence of which he had been deprived by the death of his mother. The courtship was brief, simple, and tinged by Edison's characteristic humor, and the marriage took place in 1873. Mary E. Stillwell belonged to that rare order of women who are prepared to admit the inevitable nature of certain existing conditions, and who do not exact as a primary concession to their new-fledged dignity the sacrifice of all pre-marital claims. By the exercise of this delicate tact, this wise effacement of self, Mrs. Edison's influence acquired a deeper force and subtlety, permeating the multiform strata of her husband's life, instead of constituting a personality apart, remote, chilly and exacting. She was greatly beloved by the men in Edison's employ, who to this day dwell admiringly upon her superior characteristics.

Previous to her marriage she had been a member of the inventor's working force, and despite her new dignities, ever retained an affectionate interest in her former associates. Three children, a girl and two boys, were born of this union, Marian and Thomas Alva (familiarly known as Dot and Dash), and William Leslie. Edison's marriage brought with it, amongst other good things, sundry improved hygienic conditions, notably those attaching to repose. It cannot be said that the reform was a radical one, or that the scientific sinner was not subject to frequent and alarming relapses, but on the whole certain unsuspected sparks of sanity were brought into view. Prior to his marriage Edison portioned out his hours of sleep and waking, of food and abstinence, not by the arbitrary division of light and darkness, but by the ebb and flow of the Divine afflatus. When the sacred fires of inspiration descended upon him, the vulgar requirements of hunger and fatigue were relegated to the limbo of extinct institutions, and the scientific annals of the Newark laboratory testify to the most abnormal stretches of endurance, followed, however, by equally protracted periods of rest.

On one occasion, having received an order to supply $30,000 worth of his gold and stock quotation printer, and finding that for some occult reason the new instruments refused to work, Edison immured himself on the top floor of the factory, together with a handful of scientific devotees, and conveyed to his followers the pleasing information

* Began in November issue.

that there he proposed to have them remain until such time as the printer was in smooth working order. "Now, you fellows," said the determined inventor, "I've locked the door and you'll have to stay here until this job is completed." And they did stay. Sixty hours of physical and mental work ensued, unbroken by sleep and scarcely by food, at the end of which time the difficulty was discovered and rectified. After thirty-six hours of sleep, which followed upon this phenomenal effort, Edison awoke invigorated, luminous of intellect and fully equal to the exigencies of new situations.

It has been claimed, and with perfect justice, that these extraordinary powers of physical endurance, this ability to dispense with sleep and sustenance, this swift power of recuperation could only be found in a physique the pure currents of which had never been vitiated by dissipation. A more potent argument in favor of total abstinence could hardly be adduced than that embodied in Edison's career. His severe and protracted labors owe their sustained brilliancy to no artificial stimulus ; no alcohol, morphine or cocaine have touched his lips and nature finds it comparatively easy to repair the ravages inflicted by painful and continued thought. With the generality of mental workers the cerebral tension is not merely coexistent with the period of toil, but lasts long after the object has been achieved, crowding the brain with distracting images and promoting a state of acute nervous excitement. With Edison, on the contrary, the effort at relaxation is instantaneously successful. The blood, after having served the purpose of stimulating the capillary vessels of the brain and inducing inventive capacity, soon retreats quietly to its legitimate source, and upon tired eyes, restless limbs and feverish energies descends

"The honey heavy dew of slumber,
* * * * *
Death of each day's life. Sore labor's bath."

Edison's views as to sleep were on a par with his theories in regard to diet. These were of so original and impracticable a nature that had they not been tinged with the inventor's customary humor and brought to bear upon the fine mental equipoise of his wife, carnage and conflagration must have been the result. "I wish I might never eat the same thing twice in a month," was Edison's feeling aspiration at the outset of his domestic career. We can imagine the sensations of an affectionate and inexperienced housekeeper, confronted with this unattainable desire on the part of her spouse, casting about wildly for methods wherein to embody his views and finding her ambition cramped by insufficient means, limited culinary skill, and the unkind influences of a New Jersey soil ; we can picture her envious contemplation of Mrs. Noah's superior facilities, and her fervent asseveration, like another harassed housekeeper we wot of, that "a deluge would be a trivial penalty to pay for the privilege of finding one's self on a revolutionized earth, with a brand new set of animals, vegetables and fruits."

It must not be concluded that Edison is an epicure and enslaved by the pleasures of the table. On the contrary, as we have already seen, he is singularly abstemious, eschewing all alcoholic stimulants, and averse to prolonged and heavy eating. At the same time his palate is, or perhaps we should say was, extremely capricious, craving a succession of delicate and varied cates, such as the culinary skill of our degenerate race is totally unable to supply.

He holds that a close analogy exists between physical and spiritual laws, and that considerable light may be thrown upon the dim and untrammeled confines of the human soul by an exact scrutiny of its corporeal encasement. Acting on these premises he claims that the human palate is as dependent on the variety and quality of its food as is the mind on its coresponding intellectual pabulum, and that in proportion to the elastic requirements of the diet will be the scope and potency of the mental powers. He bases these assertions on the dietary and intellectual statistics of the several nationalities, and supports

his arguments with considerable ingenuity.

"Variety," Edison remarked, "is the secret of wise eating. The nations that eat the most kinds of food are the greatest nations."

These sapient observations were delivered in 1878 over a repast so ephemeral as to remind us of Ouida's impossible banquets, where the ethereal heroine toys with a pheasant, coquets with a chocolate éclair, or trifles with the rose-hued bubbles of rare wines in a way calculated to dishearten the most enthusiastic pupil of the romantic school. A wide-eyed waiter, in obedience to the guest's instructions, brought a plate of strawberry shortcake, a dish of strawberries and cream and an apple dumpling, in conjunction with which the following themes were discussed :

"Rice-eating nations never progress," continued Edison, "they never think or act anything but rice, rice, rice for ever. Look at the potato and black bread eaters of Ireland, though naturally bright, the Irish in Ireland are enervated by the uniformity of their food. Look at the semi-savages who inhabit the Black Forest. On the other hand, what is, take it all in all, the most highly enlightened nation, the most thrifty, graceful, cultured and accomplished? Why, France of course, where the cuisine has infinite variety. When the Roman Empire was at its height the table was a marvel of diversity, they fed on nightingales' tongues and all sorts of dainty dishes. So when Carthage was in her glory"—

To the question as to whether the orator agreed with the Phœnician axiom that the stomach was the seat of wisdom, Mr. Edison emphatically assented, adding :

"Some say I get the cart before the horse, and that the diversified food is the result of a high civilization rather than its cause, but I think I am right about it. A nation begins to decay, philosophically and morally, as soon as cooking is degraded from an art to an occupation."

Mr. Edison's youthful convictions have yielded in great measure to the larger views of his ripened manhood, and it is well that this should be so, for history, whether of the past or the present, will scarcely be found to substantiate his assertions. The intellectual and moral apotheosis of a nation has not necessarily been the outcome of its perfection in and devotion to the culinary art. With the wanton splendor and profusion of the Oriental and Latinic races came the sapping of intellectual power, the degradation of the moral sense, the fatal cleavage of political unity. A sickly and mercurial sentimentality, born of wine cups, surfeits, and fetid atmospheres usurped the place of pure and constant affection ; an unreal miasma, wherein floated the diseased fancies of poetasters and pedants, supplanted the fair and potent ideals of true poetry and romance, and an illogical and unbridled license was substituted for that glorious enfranchisement which is the inalienable heritage of the sons of God. Such mental and moral endowments as owe their birth to the wine cup or the flesh pot are meretricious and ephemeral and contain no germ of that true spiritual vitality which is not only independent of carnal support, but which holds and wields its imperial prerogative of molding to its own finer purposes the gross elements of this "muddy vesture of decay."

What share had the banqueting hall of Nebuchadnezzar the King "in the knowledge and skill in all learning and wisdom" which was the portion of those pulse-fed exiles on the shores of Babylon? Could a diet, ranging from the Plutonian broths of Sparta to the artistic creations of a modern French cook, have lent greater breadth and delicacy to the multiform harmonies of Shakespeare than was evolved from the gross cates of the Elizabethan age? Could a regimen of "Herbs and such like country messes" have imparted a more delicious pastoral flavor to the *Allegretto* and the *Lycidas?* Could a beaker of Parnassus dews or a draught of Chian wine, cooled with Olympian snows and tempered by honey from the

I'VE LOCKED THE DOOR, AND YOU'LL STAY HERE TILL THE JOB IS COMPLETED.—SEE PAGE 370.

violet-scented slopes of Hymettus, have enhanced the incomparable grace and sweetness of "Una" or the "Faerie Queene"? We trow not.

However open to individual opinion Edison's views as to dietetics and repose may have been, and however unadvisable it might prove for less favored mortals to adopt his methods, the practical outcome of these early years was excellent from the standpoint of creative energy; 1874 was noted for the birth of the famous quadruplex telegraph, a partial description of which has already been given. The appearance of such an important invention could not but be attended by counter-claims, the bulk of which were enforced with extreme bitterness and complicated legal suits, but the incontestable superiority of Edison's methods gained the day, and the new system spread rapidly over the world.

The experimental work relating to the quadruplex was carried out rapidly as practicable in the Newark laboratory, but it was eventually transferred to the Western Union telegraph office in New York, where several months were spent in improving the apparatus. A complete set was finally made, and one of Edison's assistants was despatched to Boston, the instruments being arranged and manned by competent operators. In a few minutes proper adjustments were obtained, and a swift and satisfactory transmission secured, which suffered no diminution during the lengthened period of its transmission. The invention was of transcendent value and spread rapidly over the whole country. "Even the English goat," remarks Mr. Edison gleefully, "was forced to collapse and pay me a royalty for many years."

The president of the Western Union stated four years afterward in his annual report that the invention was "one of the most important in telegraphy and had saved the company $600,000 annually." At the present time the quadruplex takes the place of several million dollars worth of wires and poles.

For this magnificent invention Edison received a very modest sum, the whole of which was expended in the development of an octuplex, or instrument for transmitting eight messages simultaneously over one wire.

"This," said Mr. Edison recently, "I never completed, having taken up what is called the Acoustic Telegraph, which led to the invention of the modern commercial telephone. Bell, Gray and I were experimenting with acoustic telegraphy. Bell patented an acoustic telegraph, which was subsequently found capable of transmitting articulate speech. While this was being exhibited at Philadelphia I devised a transmitter, in which carbon was employed to translate sound into electric waves, and Gray had filed a caveat wherein water was used to vary the electric current. Bell's instrument was taken up by Boston capitalists, while mine was adopted by the Western Union, and a fierce competition ensued. It was seen by the Bell people that their instrument was impracticable for commercial purposes without my transmitter, and *pro contra* by the Western Union, that without Bell's receiver, which they did not own, my instrument was not available without extensive litigation, so a consolidation of interests took place. I met the objections to the lack of a receiver by inventing one based upon a hitherto unknown phenomenon, but the negotiations had gone too far to admit of this being utilized, and aware of my tendency to spend every thing in experimenting, I bargained that the sum paid should extend over a period of seventeen years in monthly payments, to which the company only too gladly acceded."

With the passage of time from 1870 to 1876 came the demand for increased facilities, necessitated by the extension of Edison's works. The vast and varied nature of his schemes brought many things into requisition which were unattainable in the Newark premises, illimitable as these had appeared in comparison with his former surroundings. His growing celebrity, moreover, brought with it certain penalties which were as distasteful to Edison's nature

EDISON'S MENLO PARK LABORATORY IN THE WINTER OF 1879.

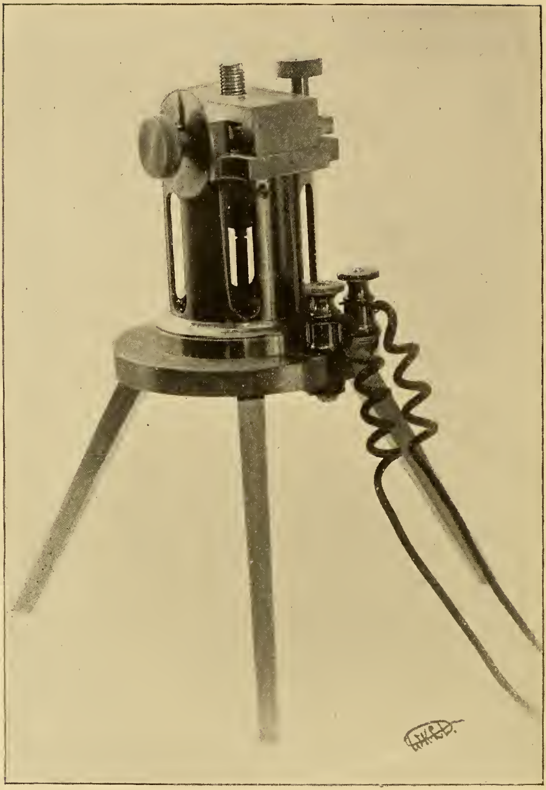
as they were destructive to his pursuits. Visitors thronged the Newark laboratory, some impelled by a genuine love of science, but the larger number actuated by mere vulgar curiosity. It was in a large measure to escape from these that Edison moved himself, his family, and his impedimenta to Menlo Park, a quiet spot on the New York and Philadelphia Railroad, at a distance of twenty-four hours from New York. There he built and fitted up a laboratory, so extensive and so magnificently appointed as to stand foremost among establishments of a kindred nature. "When the public tracks me out here," remarked Mr. Edison, "I shall simply have to take to the woods." Mr. Edison expended no less than $100,000 on his experimental apparatus alone, and the other facilities were obtained at a correspondingly high cost. A workshop, 100 feet in length, by thirty-five feet, was appointed with every mechanical detail demanded by the varied scope of science, comprising milling machines, lathes, punches, drills, planers, etc., all of exceptionable make. The power was supplied by a Brown engine of eighty horse-power. Delicate instruments of precision, models of completed machines, Morse sounders, galvanometers, telegraphic keys, a thermo pile, safe-locks and a variety of objects too numerous for classification ; these were grouped in a profusion which must have gladdened the acquisitive mind of the inventor, so long and seriously balked by the paucity of mechanical facilities. A costly scientific library, composed of the newest and most reliable works of reference, formed an important feature of the establishment, and contributed largely toward the pleasure and profit of its inmates. The upper portion of the building was well lighted, well ventilated, and commodious, walled about by an endless strata of heterogeneous articles. Rows of phials, chemical appliances, botanical specimens, rare minerals, hideous varieties of preserved snakes and other reptiles, conical paper funnels six feet high, cases of every ordinary and extraordinary device born of that prolific parent, necessity ; these, together with the usual laboratory fixtures and experimental appliances, such as microscopes, insulators, spark generators, air pumps, litre measurements, etc., were present in the most wanton variety and profusion. A pipe organ of fairly good tone and dimensions, and a diminutive music box occupied one corner of the premises, and were frequently brought into requisition whenever, in Mr. Edison's opinion, music's magic strains were needed to soothe the savage breasts of his employees. From every available quarter dangled festoons of wire, the occult possibilities of which were sufficient to ensure a respectful avoidance on the part of visitors. No one knew whether or not a pass to the other world lay concealed within these innocent-looking metallic threads, and no one was sufficiently out of touch with "this work-a-day world" to put the supposition to the test. A species of glorified mist soon enveloped "the wizard of Menlo Park," through which loomed, like spectres of the Brocken, the grotesque and exaggerated reports of his powers. By the simple inhabitants of the region he was regarded with a kind of uncanny fascination, somewhat similar to that inspired by Dr. Faustus of old, and no feat, however startling, would have been considered too great for his occult attainments. Had the skies overspreading Menlo Park been suddenly darkened by a flotilla of air-ships from the planet Mars, and had Edison been discovered in affectionate converse with a deputation of Martial scientists, the phenomenon would have been accepted as a proper concession to the scientist's genius. Tales of the wildest description as to Edison's achievements, his personal life and his business relations found ready credence, and we find The Paris Figaro of 1878 indulging in a vein of brilliant and unadulterated imagination, such as Gallic records would find it hard to outstrip. Under the thrilling title of "Cet etonnant Eddison" (This astonishing Edison), the publication launches into

EDISON AND HIS CHIEF ASSISTANTS AT MENLO PARK LABORATORY IN 1878.

details of the inventor's career, prefacing his sketch by the following lucid and eloquent description of the newly-completed aerophone. He informs the public that the Paris Exhibition is now the richer by the celebrated "Eddison's" latest invention, the stupendous aerophone, of which the workings may be thus briefly outlined: "It is a steam machine which carries the voice a distance of eight kilometres. You speak in the jet of vapor; a friend previously warned understands readily words at a distance of two leagues. Let us add that the friend can answer you by the same method." It would be superfluous to enlarge on the profundity and clarity of this unique description. We will, therefore, proceed with The Figaro's further revelations, which cannot but possess the merit of entire novelty to the reader. "It should be understood," continues our Gallic oracle, "that Mr. Eddison does not belong to himself; he is the property of the Telegraph company, which lodges him in New York at a superb hotel, keeps him on a luxurious footing and pays him a formidable salary, so as to be the one to know of and profit by his discoveries. This company has in the dwelling of Eddison, men in its employ, who do not quit him for a moment, at the table, on the street, in the laboratory. So that this wretched man, watched as never was a malefactor, cannot give a second's thought to his personal affairs without one of his guards saying: 'Mr. Eddison, à quoi pensez-vous?'" It is amusing to compare this figment of a callow reporter's imagination with the true and unvarnished facts. "Cet etonnant Eddison" was indeed a sufficiently astonishing individual in the estimation of his employers to enjoy their confidence and respect, but had that respectful treatment been withheld, Edison's sturdy nature would have known how to command it. As a matter of fact, his scientific investigations were absolutely free from espionage, and his flow of genius untrammeled by interference or suspicion. He was singularly fortunate, moreover, in gathering about him elements of a congenial nature, and in welding these into one efficient and harmonious whole. A corps of skilled mechanics had been secured at the outset of the new enterprise, and a staff of competent assistants, foremost amongst whom was Mr. Charles Bachelor, a gentleman upon whose recognized ability it seems almost superfluous to enlarge. A native of London, England, Mr. Bachelor's sturdy Saxon mind had grafted upon its intrinsic solidity of attainment the acute brilliancy peculiar to this rarefied American air, together with the alert business capacity so necessary to worldly success. This rare combination of intellectual and commercial powers had made him indispensable to Mr. Edison, with whom he had been closely connected since the year 1870. Well has it been said in regard to the relations subsisting between the two friends and associates: "If a historical parallel will be allowable, Mr. Bachelor is to Mr. Edison what Father Mersenne was to the great Pascal, the celebrated scientist, scholar, and inventor of the arithmetic machine."

Under Mr. Bachelor's supervision were placed eleven of the most skillful machinists and instrument workers attainable. Prof. McIntyre, a scholar of no mean reputation, with two competent assistants, carried out the scientific experiments, invariably outlined by the inventor himself; while Mr. L. S. Griffin, his life-long friend and former telegraphic manager, assumed the congenial task of private secretaryship, promoting, by his affectionate and intelligent zeal, the confidential interests of his employer. Mr. John Kreuzi officiated as master machinist, and William Carman as bookkeeper. The services of the entire force were on a salaried basis, with the exception of Mr. Charles Bachelor, to whom, in view of his valuable co-operation, an interest upon each invention was paid.

The genius of good will, whose presence had been so marked a feature in the Newark laboratory, found a congenial abiding place in Edison's new surroundings, and the social machinery



THE EDISON ODOROSCOPE.

moved as smoothly as the complicated gear, lubricated by spiritual substances infinitely more potent and subtle than material oils.

The micro-tasimeter, or instrument for measuring inappreciable degrees of heat, was now evolved, being based, as the reader will remember, upon the variable resistance of carbon under electrical pressure. The name is taken from two Greek words, meaning respectively measure and extension, for the reason that broadly understood the office of the instrument is primarily to measure extension of any nature whatever. The principles underlying this delicate mechanism are thus described by Mr. Edison : "It consists of a carbon button placed between two metallic plates. A current of electricity is passed through one plate, then through the carbon, and through the other plate. A piece of hard rubber or of gelatine is so supported as to press against these plates. The whole is then placed in connection with a galvanometer and an electric battery. Heat causes the strip of rubber to expand and press the plates closer together on the carbon, allows more current to pass

through and deflects the needle of the galvanometer. Cold decreases the pressure. Moisture near the strip of the gelatine can be measured in the same way by increasing or decreasing the pressure, and accordingly deflecting the needle. By means of this apparatus, or one combined with sensitive electrical galvanometers, it is possible to measure the millionth part of a degree Fahrenheit."

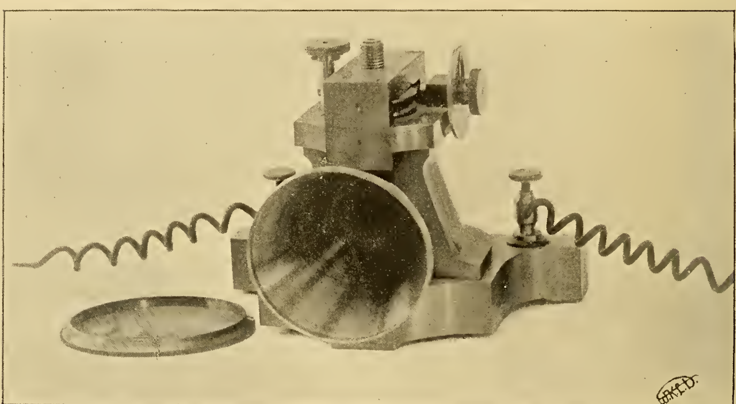
That suggestive poetry which has a knack of filtering through our most prosaic themes leavened the first experiments of the tasimeter. On one occasion Edison heated the handle of a telephone and immediately after spoke through it to his trusty confederate, Mr. Charles Bachelor. That gentleman promptly replied, in somewhat excited tones, "Why, Edison, what are you doing there? Where does that music come from?" Edison disclaimed the existence of music at his end of the line, but repeated tests secured similar effects, and the fact was established that a musical note of peculiar sweetness and sonority could be produced at intervals of five seconds, resulting, as subsequent investigations proved, from the gradual contraction of the molecules in the process of cooling. This curious phenomenon was named by Mr. Edison, "molecular music."

Had Pythagoras been personally conducting that memorable experiment, he would probably have detected in those silvery monotones some distant re-echoes of his own beloved strains, the hypothetical march of the planets. As it is, what unsuspected harmonies may not be awaiting us in the unexplored regions of molecular sounds?

On July 9, 1878, at Rawlings, Wy. Ter., and on the occasion of the sun's total eclipse, the tasimeter was subjected to its first crucial test, under circumstances of a somewhat adverse nature, and in a shrine the nature of which was calculated to shock any youthful romance which may have lingered in the young scientist's breast. On Edison's arrival at the seat of operations, he found that every available structure had been seized upon and utilized by the innumerable crowd whom curiosity or scientific ardor had attracted to the spot, and that the only edifice at his command was a dilapidated hen-house. Here he established himself, with his various impedimenta. A stable and level basis was the first indispensable requirement of the delicately sensitive apparatus, and this element was conspicuous by its absence on the present occasion. Not only was the hen-house in the last stage of consistent decay, but a blizzard was in progress second only to Mark Twain's celebarted Washoe zephyr, or the antics of Odysseus' escaped breezes. Edison's observatory began to rock in the most ominous manner, and one side assumed a pensive angle resembling that of the leaning tower of Pisa. Each vibration affected the condition of the tasimeter, and brought new adjustments into requisition. Time was coursing swiftly, and the supreme moment of observation was at hand. The assembled scientists were quivering with pent-up excitement, and the success or non-success of the new invention was not the least important theme of speculation. Edison surveyed his tottering structure in momentary despair, while the wild winds played havoc with his raiment and with his scientific apparatus. The storm had descended in too violent and unexpected a manner, and the time was too short for demolishing and reconstructing, therefore Edison did the only thing possible under the circumstances. Tearing into a neighboring lumber yard, he impressed a dozen burly men into service, and succeeded with their help in propping up the side of the hen-house, besides erecting a broad fence wherewith to break the force of the tornado. Scarcely were these preparations completed when the chronometer indicated half-past one o'clock. At thirteen minutes after two the moon began her passage between the sun and the earth. The tasimeter was again adjusted, but so violent were the oscillations communicated to the projected telescope, through the violence of the gale, that no satisfactory results could be ob-

tained. A partial equilibrium was secured by a hasty arrangement of wires and ropes, the instruments were again adjusted, and simultaneously with Dr. Draper's excited announcement, "there she goes," the smoked glasses of innumerable spectators were riveted on the celestial phenomenon. The progress of the moon was slowly traced through the successive hours and no difficulties were experienced except the ones in connection with Edison's gallinacious and recalcitrant structure. At five minutes past 3 P. M., the sun's disk was seven-eighths covered, and the surrounding country loomed faintly through a dim, sepulchral light. At a quarter past three all animal life was quiescent, and darkness was on the face of the earth. Still the tornado howled and rampaged, and that miserable tasimeter meekly took its cue from the raging elements. Pitted against the forces of nature, Edison stood his ground valiantly, adjusting and readjusting his instruments, until at length, when but one precious moment remained of total eclipse, he succeeded in concentrating the light from the corona upon the opening of the tasimeter, registering the existence of about fifteen times more heat than was discoverable the night before from the star Arcturus. Accurate results, however, were impossible owing to the shortness of time, but one important principle was obtained and cherished in the inventor's mind for further investigation. Not only was the capacity of the instrument found sufficient for the registration of the desired phenomenon, but it was discovered that the heat from the sun's corona went ten times beyond the index capacity of the instrument.

This event brought the tasimeter into prominent notice, and a writer in The Scientific American of October, 1878, said: "Seeing that the tasimeter is affected by a wider range of etheric undulations than the eye can take cognizance of, and is withal far more acutely sensitive, the probabilities are that it will open up hitherto inaccessible regions of space and possibly extend the range of aerial knowledge as far beyond the limit obtained by the telescope as that is beyond the narrow reach of unaided vision. Possibly, too, it may bring within human ken a vast multitude of nearer bodies—burnt out suns or feebly



EDISON'S MICRO-TASIMETER.

reflecting planets, now unknown because not luminous.''

It is almost impossible for the human mind to realize the fairy-like sensitiveness of the tasimeter. Innumerable experiments were made by Mr. Edison and others which tended toward the demonstration of this fact, and of these we cull the following. In a letter of the inventor to Mr. W. F. Barrett, Royal College of Science for Ireland, Dublin, in 1878, Edison says: "By holding a lighted cigar several feet away I have thrown the light right off the scale, and by increasing the delicacy of the galvanometer the tasimeter may be made so sensitive that the heat from your body, while standing eight feet away from and in a line with the cone, will throw the light off the scale and the radiance from a gas jet 100 feet away gives a sensible deflection.''

The pressure of moisture is susceptible of the same minute observations, making the principles involved an excellent basis for the construction of barometers, hydrometers and other appliances for discovering atmospheric conditions. On one occasion, in the early days of his experiments, Mr. Edison placed a strip of gelatine between the upright pieces of carbon. He then held a strip of damp paper three inches away from the gelatine, which instantly produced an expansion of the latter and caused the needle to shift eight degrees. A drop of water on the tip of the finger, held five inches away, deflected the needle eleven degrees. An important application of these principles is embodied in the detection of icebergs at sea. The carbon button, with its pressing rod, is enclosed in a case, connected with the keel of a ship, and linked by wires running from a constant and weak Daniell battery to an ordinary galvanometer in the captain's room. Cold causes the compressing rod to contract and warmth to expand, and the deflections corresponding to these phenomena are brought at once under the captain's notice, so promptly as to allow ample time for precautions. Long before this ice-mailed colossus of the seas can bear down upon its fragile antagonist, the latter has taken an ingenious *volte de face*, and is skimming merrily in the opposite direction. The sudden breaking out of fires may be chronicled with the same certainty and promptitude.

The conditions relating to the registration of moisture belong properly to the province of the odoroscope, a modification of the tasimeter, and so named primarily from its ability to measure odors inappreciable to the unaided senses.

Various instruments for the projection, registration and amplification of sound were then rapidly evolved. To this order belong, among others, the microphone, the megaphone, the phonograph, and an application of phonographic principles called the aerophone.

(*To be continued.*)

PRACTICAL NOTES ON THE STEAM JACKET.

By W. Fletcher.

OF all the details of the steam engine invented by the illustrious Watt, the steam jacket is probably the simplest. Yet the utility of this very simple device has from the earliest times been the subject of considerable contention among engineers; it is astonishing, however, to find how much has been written on steam jacketing, and how little information of a useful kind has been imparted. During recent years much valuable space has been devoted by our technical papers to useless discussions, and theoretical notions; but no one, to our knowledge, has given any practical information respecting the misapplication of the steam jacket, previous to the author's little book on this subject.* The want of information of a practical type is one of the chief causes of this endless contention respecting the utility of the steam jacket; because it has been proved to demonstration, that properly applied steam jackets promote economy of fuel, and further, without efficient steam jacketing economy in the true sense of the term is an impossibility.

Many of the people who denounce the steam jacket possess little knowledge of its function, are therefore unable to design it properly, and the unsatisfactory results obtained from the tests carried out on counterfeit jackets have not, of course, influenced them to alter their opinion. It is not unusual to meet with engine-makers who understand everything connected with the steam engine except the jacket around the cylinder, and this simple device is to them shrouded in mystery; the moment they attempt to explain its use, they become hopelessly entangled.

One writer says: Almost every engineer knows nowadays that a cylinder should be kept as hot as possible; but very few makers of steam engines understand the precise reasons why a cylinder should be kept hot.

It is probably owing to the lack of information respecting steam jacketing that accounts for the number of modern engines now turned out from English, American, and other works, having jackets, which, to say the least, are of doubtful advantage, if not positively detrimental, owing to grave constructive faults.

The editor of Engineering some time ago remarked: "To secure the advantages of steam jacketing, it is not sufficient to merely place around the cylinder a casing that may contain steam, care must be taken that this jacket always does contain steam. Few but those who have actually tried it fully appreciate how soon a jacket may be rendered ineffective by the accumulation of air or water." No one who has given the slightest attention to this subject can have failed to notice that notwithstanding the many cylinders which are said to be jacketed, how very few are really steam jacketed, thoroughly and efficiently.

Practical experience confirms the truth of the above remarks, as will be gathered from the instances of counterfeit jacketing now to be recorded. We shall state some of the requirements of efficient steam jacketing, and test a few modern cylinder sections by these principles, to ascertain whether the jackets are arranged so as to secure perfect success or not.

1. The jacket should completely encircle the cylinder from end to end. In numerous examples the jacket is only carried partly round the cylinder, in some cases only two-thirds round it.

* "The Abuse of the Steam Jacket Practically Considered," by W. Fletcher, New York. E. and F. N. Spon, 12 Cortlandt street.

Figs. 1 and 3 illustrate this fault. But in those cylinders which have the liners cast separately, and inserted into the casing so as to form the steam jacket, this point is fully carried out, as shown by Fig. 2.

2. The exhaust chamber should present as small a portion of surface to the

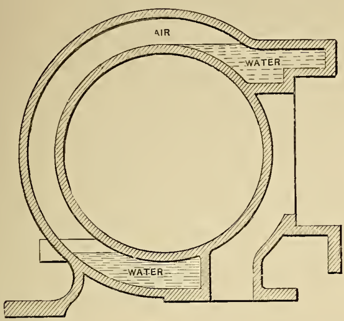


FIG. 1.

jacket steam as possible, and in no case should the exhaust steam be made to travel partly round the cylinder, either in contact with the steam in the working body of the cylinder, or the steam in the jacket. Fig. 2 shows a large area of the jacket surface exposed to the exhaust steam, while in Fig. 3 a large surface of the working barrel is being cooled by the same cause. Fig. 4 shows an otherwise neatly designed Corliss engine cylinder with this grave defect, the whole of the bottom side of the steam jacket is in contact with an enormous exhaust chamber. How much better it would have been if the exhaust steam had been taken away through the cylinder foot at each end, and thus have saved this dissipating process. At one time it was a very usual thing to jacket cylinders with exhaust steam, but such mischievous jackets are now unknown; still there are many cylinders which have large areas of surface exposed to the damp and cool exhaust, by means of which a large amount of heat is drawn from the working steam. To prevent this waste, the exhaust should be made to pass quickly away from the cylinder, by as direct and short a course as possible, which in many instances is very easily done. In many Corliss engine cylinders these short passages prevail. Fig. 5, shows an excellent example.

Some of our readers may think these exhaust passages are trifling matters to write about, but we must remember that the damp and cool exhaust steam possesses a notorious propensity for dissipating heat, and if it is allowed to come in contact with the metal heated by the working steam, it will counteract to a great extent the good effects rendered by the steam jackets. Economy of steam is brought about by our attention to a number of small matters, each of which in itself appears very insignificant.

3. The jacket must be supplied with steam of the full boiler pressure, that is, there should always be steam in the jacket as high as the highest steam in the working cylinder; in some cases the jackets have been supplied with steam of a higher temperature than the

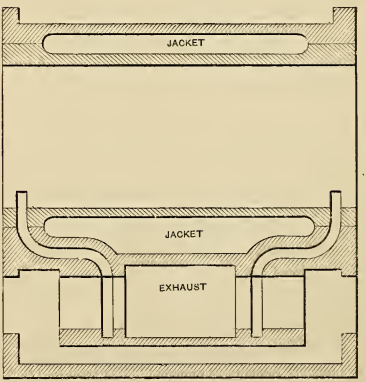


FIG 2.

working steam, the jacket supply being provided by a separate boiler when the utmost economy of steam has been secured. But this system of jacketing can rarely be adopted. In order to have the jackets charged with steam of the full boiler pressure, the supply pipe must be of ample area. These essential requirements must have been under-

stood by Murdock, Trenthick, and others, who inserted the cylinder in the steam space of the boiler. Let us see how these essential conditions are complied with by the engine-builders of the present generation. The steam supply pipes for the jackets of marine engines,

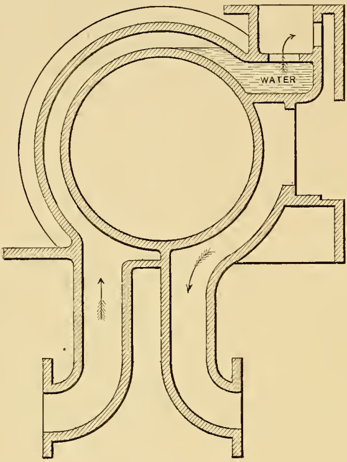


FIG. 3.

instead of always being open to the boiler, are generally provided with cocks, the engineer can therefore shut off the steam, if he imagines this to be desirable. Many steam jackets of land engines are supplied with steam by means of a very small pipe, which connects the jacket with the main steam pipe above the engine stop valve. These jacket supply pipes are often much too small for the purpose. A large number of stationary engines receive the jacket steam from the valve chest. These examples have not steam of the full boiler pressure in the jackets, and the supply being affected by the stop valve, the cylinders are not hot ready for work ; therefore the engine must be started very slowly in order to warm up the cylinder, and to allow the condensed steam to run away. Fig. 6 shows a sectional view of a cylinder, with the jacket supplied from the valve chest, but, worse still, the pipe is also carried through the exhaust chamber, in order to further reduce the temperature of the jacket steam.

4. Not only should high pressure steam be used in the jacket, but if we are to realize the best results, we must have the working steam as dry as possible, because all wet steam admitted into the cylinder is evaporated during the stroke by heat abstracted from the jacket. It follows that the working steam should not be made to traverse round the jacket previous to entering the cylinder, for by so doing the steam is robbed of its heat, and condensed, before it reaches the cylinder, the water resulting from this refrigeration being carried with the steam into the cylinder. Figs. 3 and 7 are illustrations of this class, the jacket may be said to drain itself through the cylinder. In many compound engines of large sizes the steam on its way to the high pressure cylinder passes round the jacket of the

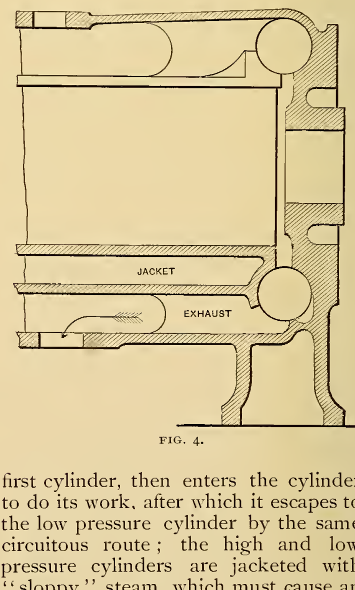


FIG. 4.

first cylinder, then enters the cylinder to do its work, after which it escapes to the low pressure cylinder by the same circuitous route ; the high and low pressure cylinders are jacketed with "sloppy" steam, which must cause an immense loss. We noticed in one of

the engineering journals a compound side by side stationary engine, in which the steam on its way to the high pressure cylinder traversed an interheater, then passed round the cylinders in the manner indicated above ; such a plan of transmitting heat to the working steam, at the expense of steam just about to do work is not at all an advisable one. The almost inevitable result is to make the steam so wet, that the benefits gained by jacketing and re-heating are more than counterbalanced. The steam pipes from the boilers should have provisions

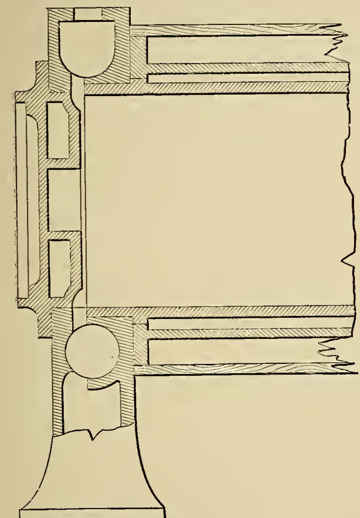


FIG. 5.

for draining, so as to prevent the condensed steam being carried into the cylinders. We believe that priming boilers are more numerous than some people imagine, and much of the water we are sometimes troubled with probably comes from this source, causing an enormous loss of power.

5. The steam supply pipe should enter the jacket at such a point that a thorough circulation of the steam within may be secured and maintained, and the accumulation of air at any part of the jacket made impossible. Fig. 1 shows a section of a cylinder, the jacket of which is so badly arranged that no circulation of the steam takes place, and air collects at the top. It is of the utmost importance that the jacket steam

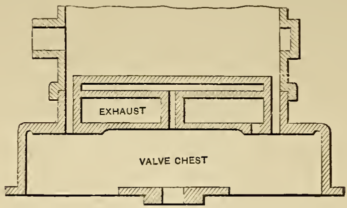


FIG. 6.

should be taken in at the top of the cylinder, and a thorough circulation obtained. The neglect of this precaution has at numerous times led to most unsatisfactory results. At a trial of steam engines some time ago, one of the engines possessed an inefficient steam jacket, the steam was admitted at the bottom, and no circulation took place ; therefore, when there was sixty pounds pressure of steam in the bottom part of

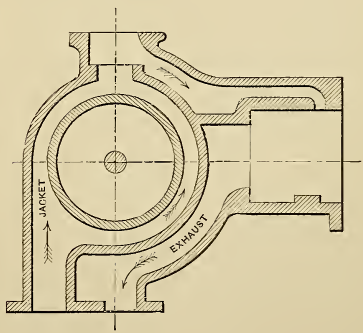


FIG. 7.

the jacket, the top part remained quite cold.

6. It is essential that the provisions made for the drainage of the jacket should be most efficient and complete ; to fully answer their end, they should

be so planned that they continually operate, irrespective of any control from the attendant.

This defective drainage is the most prevalent and by far the most serious evil which the steam jacket has to contend with, and it is an abuse which is working greater mischief than all the other detrimental causes combined. In many instances the drainage of the steam jacket is most unsatisfactory, and in some cases it is practically omitted altogether. By the neglect of this seemingly trifling matter, an otherwise well-devised steam jacket can be transformed from an economizing agent to the veriest sham, acting as a surface condenser, and thereby aggravating to an alarming extent the very evil it was intended to diminish. Fig. 1 represents an example wherein the bottom of the jacket will always contain some water, because the jacket drain cock is several inches above the bottom of the jacket; instances of a similar nature could be multiplied. But we have known many cylinders in which the bottom part of the jacket has been drained, but owing to defects of construction, water has found some pocket where it may lodge in the higher part of the jacket space. Figs. 1 and 3 are examples of this species of defective drainage; in the case of Fig. 3, the steam is first of all cooled by being made to traverse round the jacket space, and before it reaches the stop valve it must pass over a body of water, and probably carry some of the water into the cylinder.

In many stationary engines it is practicable to have the cylinder fixed at a sufficient elevation above the boiler to admit of the jacket draining itself by gravitation, the pipe for this purpose entering the boiler below the water line; where this cannot be carried out, the drain pipe should always be connected to an automatic steam trap.

7. The working barrel of the cylinder should be made as thin as possible and of the best conductor of heat. The thickness of the metal of the liner is of great importance, because the transmission of heat, both in time and quantity, is inversely as the distance passed through, and therefore the shorter such distance the more efficacious will be the steam in the jackets. The system of forming the cylinder casing and the bush separately is now becoming universal, consequently thin liners follow in its train. Steel liners are now adopted for all classes of engines with success.

For want of space we have omitted to mention other causes which often counteract the beneficial effects of the steam jacket, but with these facts before us, it is our duty previous to accepting any of the startling figures said to be the results of tests with, and without, steam jackets, to ascertain for ourselves: 1st, that the engineers engaged in the tests understand the function of the steam jacket; and 2d, that the so-called jacket is really an efficient steam jacket; for unless we are in possession of this information, the publication of a lot of tables and figures teach nothing, and are of no practical value. Whenever the steam jacket has been well applied, and properly tested, its utility has been proved beyond a doubt, but in too many instances we fear, some of the miserable counterfeit jackets we have alluded to (instead of the real article) have been tried, which explains the mistaken notions in vogue as to its utility, and the nonsense that is occasionally expressed in some quarters respecting it.

THE NIAGARA TURBINES.

By Clemens Herschel, Hydraulic Engineer, M. Am. Soc. C. E., M. Inst. C. E.

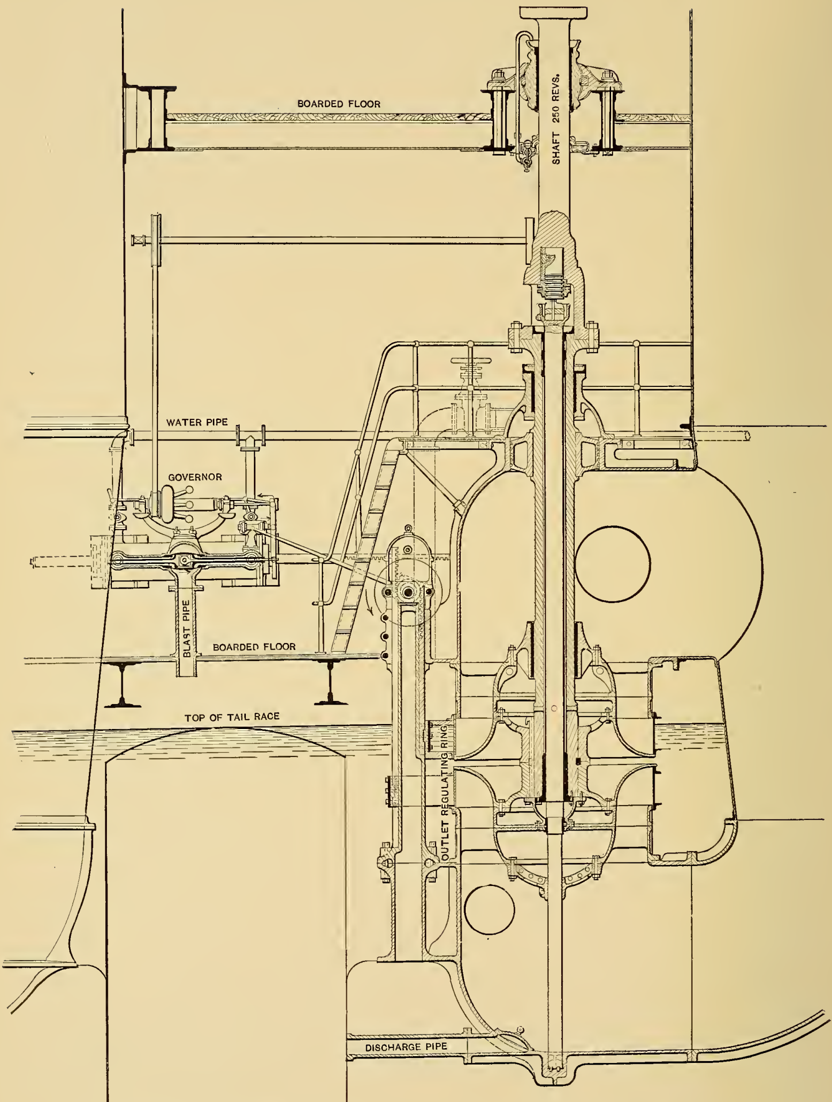
IT is but natural that a work of the magnitude and novelty appertaining to the utilization of the first lot of 100,000 horse-power at the Falls of Niagara, should have given rise, in the course of its construction, to many new methods and structures. Some of these, as for example, its most noted characteristic, the tunnel tail-race, lined with brick, and the special construction of the portal of the tunnel; the wheel pit slot of the Central Power Station, instead of the usual single wheel-pits; the setting of the wheels directly over their branch tail-race, and deepening the slot to form this branch tail-race; and other features of the work, have already been referred to and described in this magazine. It is proposed in this sketch to speak only of the motors under contract, and ot others that have been proposed for the development of power on these mill-sites.

The fashionable turbine of the present day, in the United States, is, no doubt, the twin turbine, with horizontal axis; this axis projecting from the wheel case, at one or both ends, and either driving its attached machine directly, or carrying a pulley, to belt from. And several attempts have been made to fit this general form of motive power for the case in hand. These all failed, from the great space required for the belts or drive-ropes, which, in this case, would have had to be gained at the price of a material increase in the amount of rock excavation. Not to transmit the power to the surface of the ground, and to attach the machinery underground, brings with it the necessity of excavated chambers 140 feet below the surface, liable to be damp, or wet, and requiring constant artificial light; in short, forming a likewise undesirable arrangement. These considerations led, therefore, in the case of the Central Power Station, to wheels with vertical shafts, and, as has been described, to rows of such wheels, set in a continuous slot, directly over the appurtenant tail-race; and to a group of such wheels, set in a square pit, for the Niagara Falls Paper Company.

Considerations of economy in regard to rock excavation per horse-power developed, led to large quantities of power per wheel; actually, to some 1100 horse-power per wheel, in case of the Paper Company; and to 5000 horse-power, in case of the Central Power Station. The very idea of a Central Power Station serves, by the way, to meet considerations of economy in rock excavation, by avoiding the necessity of constructing wheel-pits, to supply only small powers. When such small blocks of power are wanted, they will be furnished as parts of a larger plant, by transmitted power, as it would not pay to sink a wheel pit for them alone. We may say, in round figures, that blocks of between 500 and 1000 horse-power, will probably, and of less than 500 horse-power, will certainly, be furnished on these mill-sites by transmitted power; and the Niagara Falls Power Company is contemplating such transmission and distribution of power, by electricity.

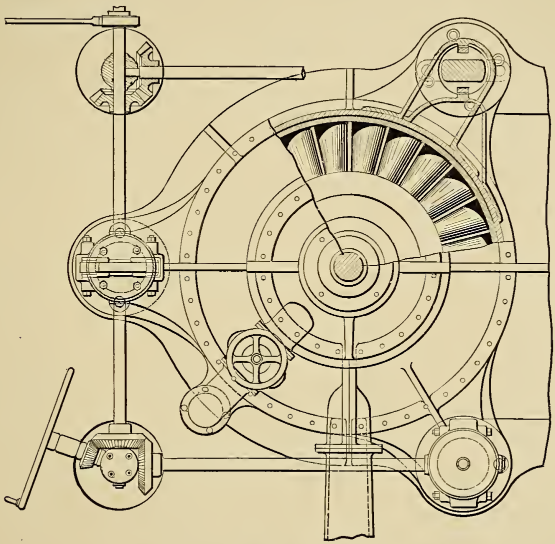
Given, then, turbines with vertical shafts of 5000 horse-power and on about 140 feet fall, it follows that American wheel builders are not accustomed or fitted to supply such wheels.

The turbine wheel business in the United States is, in point of fact, carried on in a way entirely different from the way the same business is carried on in Europe. While wheels built to order are the exception in this country,



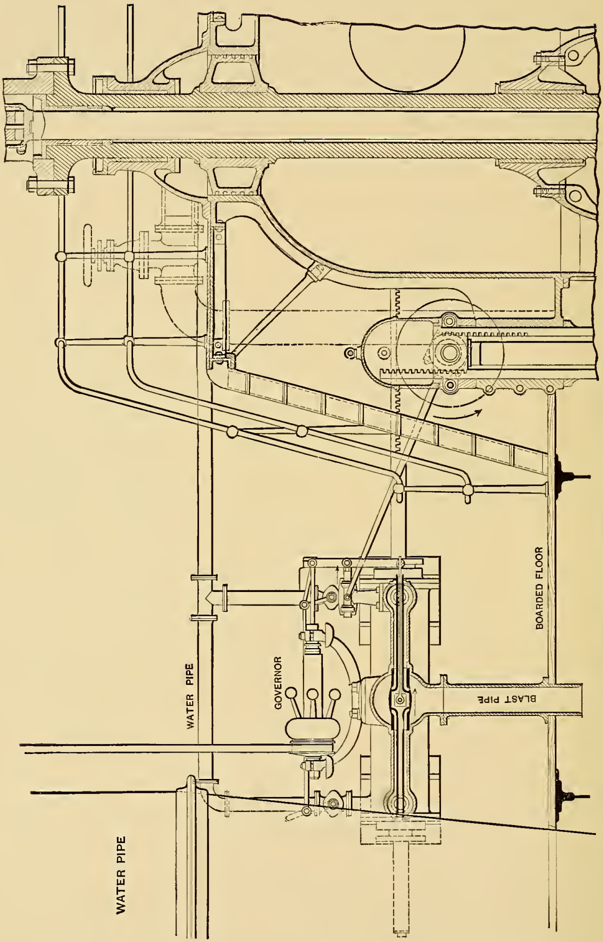
SECTIONAL PLAN OF WHEELS AND GOVERNOR FOR NIAGARA FALLS. ESCHER, WYSS & CO. DESIGN.

they are all but the invariable rule in Europe; and, while our builders have, ordinarily, stocks of wheels on hand, and turn them out as they would shelf hardware, wheels built in that way in Europe would prove there entirely unsalable. Our wheels are mostly of a complex nature, as regards the action of the water on the buckets of the wheel, and have been perfected in efficiency by test, or, as it has irreverently been called, by the "cut and try" method of procedure. A wheel would be built on inspiration of the inventor, then tested in a testing flume, changed in a certain part, and retested until no further change in that particular could effect an improvement; another part would then undergo the same process of reaching perfection; and thus in course of time the whole wheel would be brought up to the desired high standard of efficiency. European wheels, on the other hand, are mostly of the standard simple action kinds, and have been perfected mainly by learned computations of forms of guides and buckets. Most of our builders also shun high falls, and, in their work, turned out in quantity, aim to suit only the ordinary run of falls. The one especial high fall wheel built in the United States, the Pelton wheel, has a horizontal axis. To use it on a vertical axis, and with the multiplicity of nozzles required for producing 5000 horse-power at Niagara, would constitute practically a new wheel.



JONVAL WHEEL. ESCHER, WYSS & CO. DESIGN.

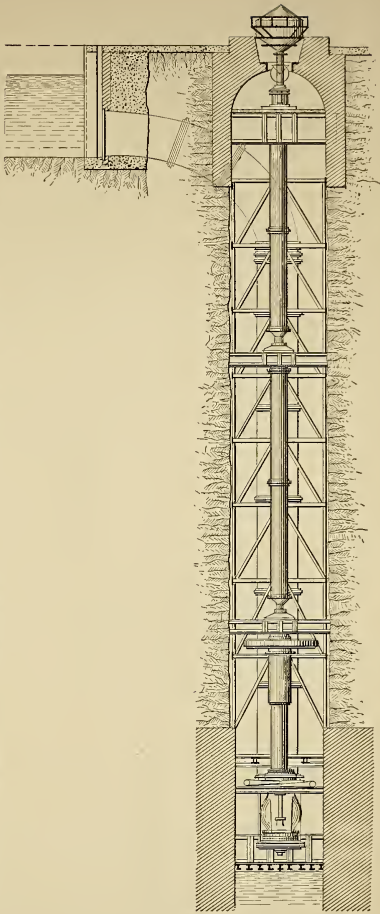
Swiss, and other European wheel builders, were, therefore, early in the field with designs for producing 5000 horse-power under a 140 foot fall, which, with their constant practice in building wheels to order, was, to them, only a case to be met like most any other. The European designs all appreciated the difficulty of constructing a step, or bearings, that would sustain the great weight of a column of water 140 feet high, added to the weight of the shaft itself, and even of the armature of a



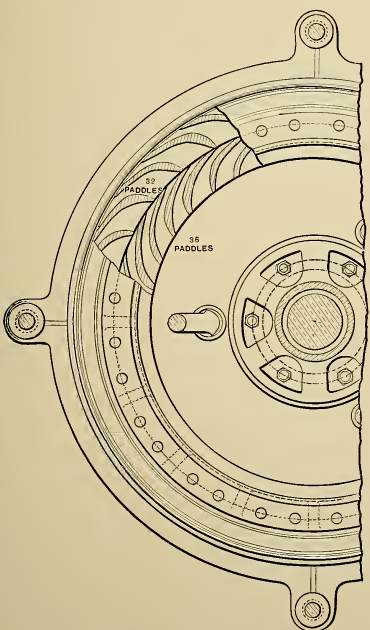
SECTION OF GOVERNOR. ESCHER, WYSS & CO. DESIGN.

dynamo set on top of the shaft. To meet this requirement of construction, some designed oil, or water bearings, along the line of the shaft; some designed hollow shafts, with an oil bearing on top of a column, ending near the top of the wheel—the so-called Fontaine step; others designed a water piston bearing; others hit upon the idea of having twin wheels set, the one larger in diameter and vertically over the other, and thus neutralizing the weight of the column of water acting on the wheels; and, finally, we have also a combination of certain of these methods of bearing, safely, the great weight on the revolving parts that support the wheel and the weights upon the shaft.

The wheels themselves, it is agreed among European turbine builders, must be either of the Fourneyron, here often called Boyden, type, or else, Jonval wheels. The 1100 horse-power tur-

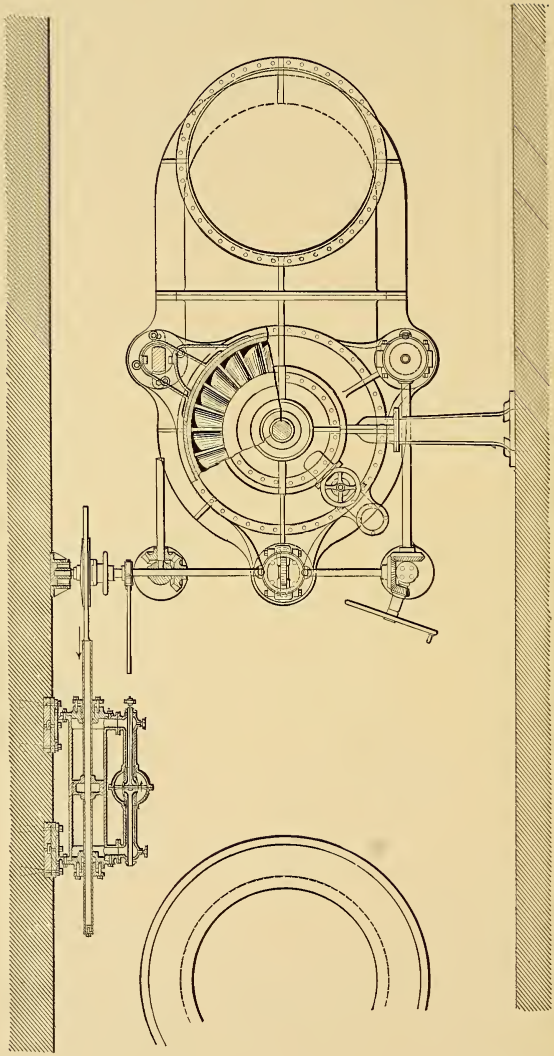


FAESCH & PICCARD DESIGN.



HALF SECTIONAL PLAN OF WHEEL.
FAESCH & PICCARD DESIGNS.

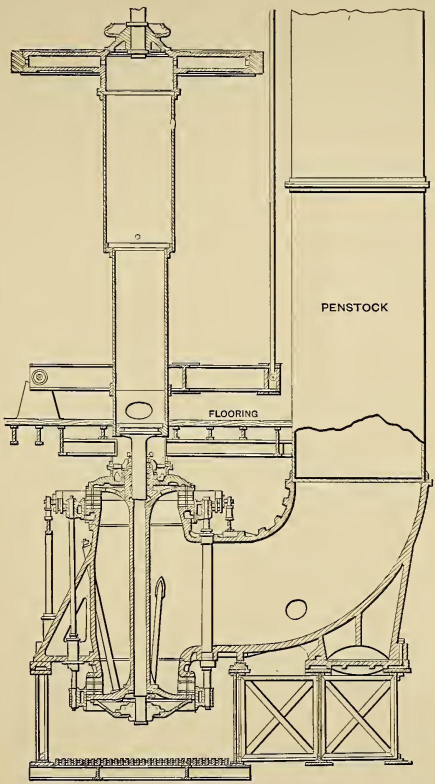
bines ordered by the Niagara Falls Paper Company are of the Jonval type, designed and built by R. D. Wood & Co., of Philadelphia, under the direction of the veteran Jonval wheel builder in this country, Mr. E. Geyelin, and are very much like the Jonval wheels described below as submitted to the Niagara Falls Power Company by Escher,



PLAN VIEW OF WHEEL. ESCHER, WYSS & CO. DESIGN.

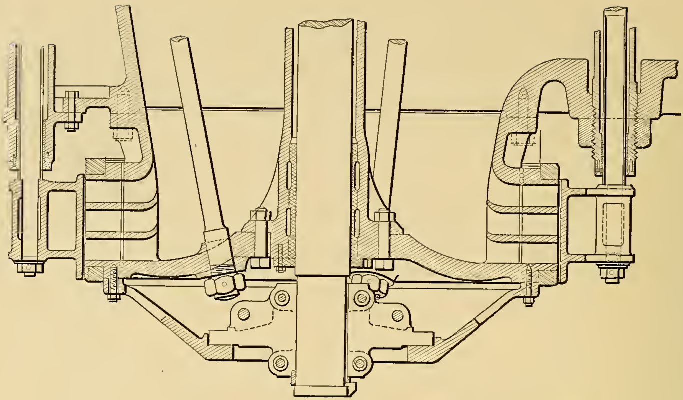
Wyss & Co., of Zurich, but omitting the upper of the twin wheels.

The first two wheels actually under contract for the Niagara Falls Power Company were designed by Faesch & Piccard, of Geneva, Switzerland, and are being built under contract with the I. P. Morris Co., of Philadelphia. They consist of two Fourneyron turbines, set, the one inverted and vertically over the other, so as to neutralize weight on the step, or bearing. Each of these twin wheels is, moreover, made three stories high, or deep, and the speed-gate consists of a cylindrical rim, moving up and down on the outside of each wheel. To further neutralize weight on the upper bearings of the shaft, the water from the penstock is allowed to pass through the disc of the upper guide-wheel, and to act vertically upward upon the disc of the upper turbine wheel. The disc of the lower guide-wheel is, on the other hand, solid, and the weight of water upon it is supported by three inclined rods passing through it and the wheel casing.

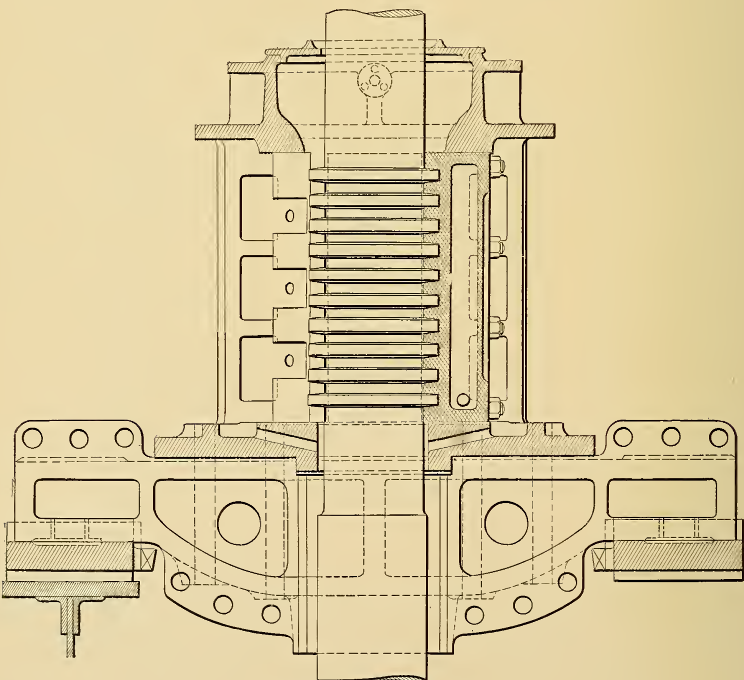


SECTION OF TURBINES. FAESCH & PICCARD DESIGNS.

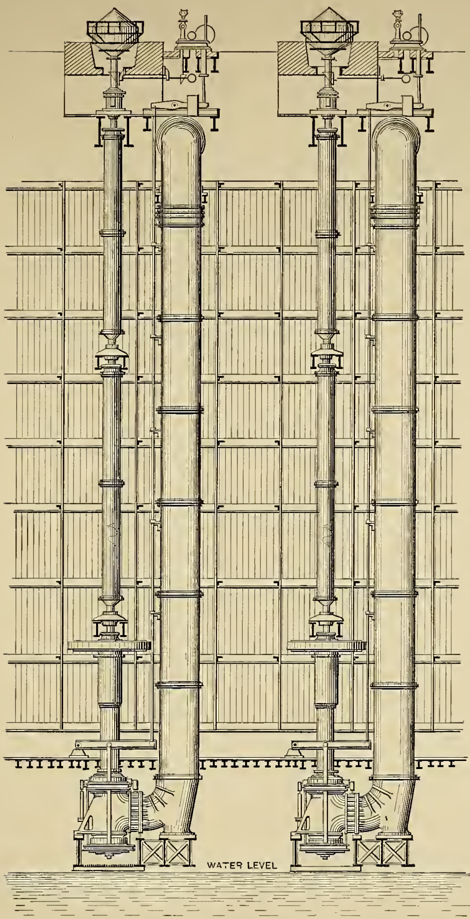
These wheels will discharge 430 cubic



VERTICAL SECTION THROUGH LOWER WHEEL. FAESCH & PICCARD DESIGNS.



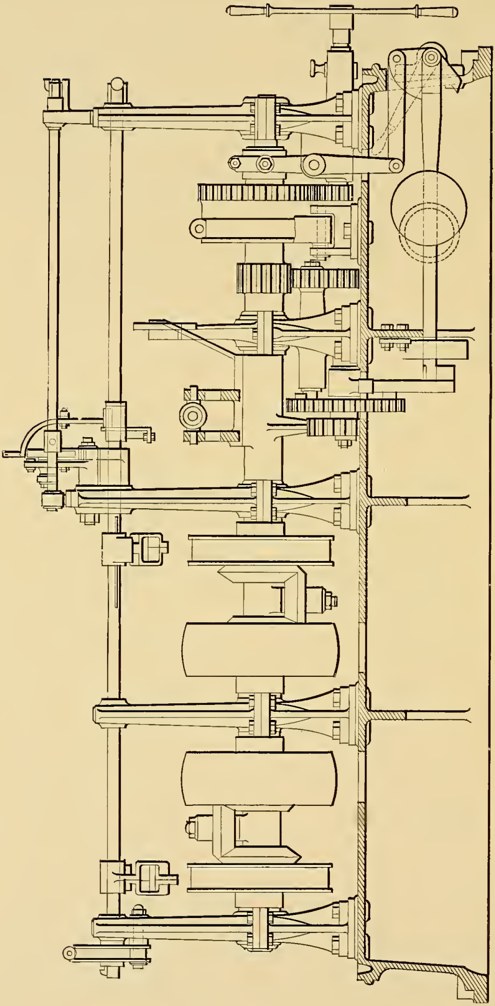
FAESCH & PICCARD DESIGNS.



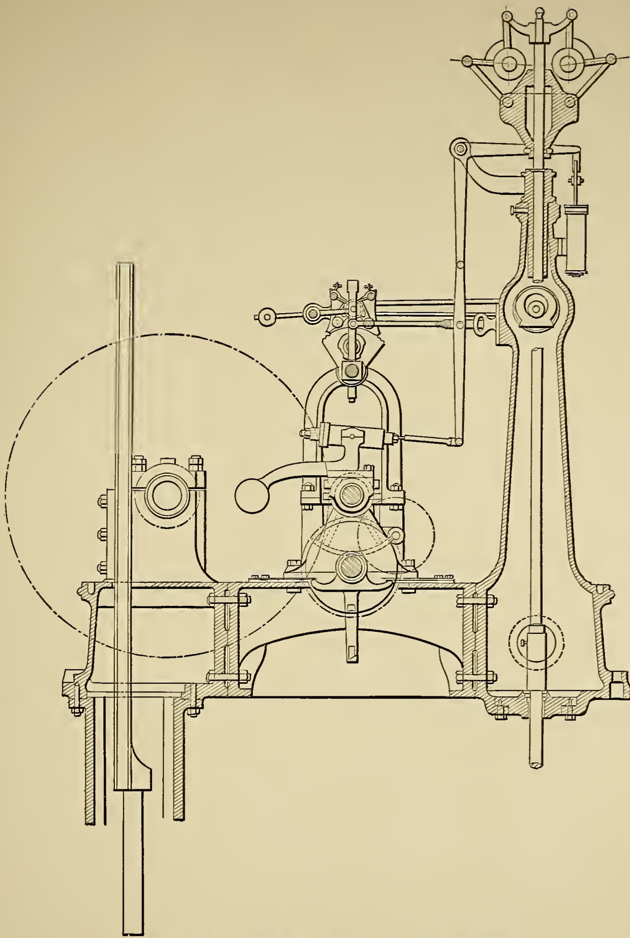
GENERAL PLAN. FAESCH & PICCARD DESIGN.

feet per second, and, acting under 136 feet fall from surface of the upper water, to the centre between the upper and lower wheels, will make 250 revolutions per minute, and at 75 per cent. efficiency, will give 5000 horse-power. The guide wheel has 36 buckets, the turbine wheel 32. These buckets are thickened in the middle, this being the most approved form of bucket, especially useful when the wheel is acting at part gate. It is proposed to make the turbine wheels of bronze, the rim and buckets forming a single casting.

The shaft is a steel tube, 38 inches in diameter, except at points where it passes the journal bearings, or guides, at which point it is 11 inches in di-



SECTIONAL VIEW OF GOVERNOR. FAESCH & PICCARD DESIGNS.



SECTION OF GOVERNOR. FAESCH & PICCARD DESIGNS.

ameter, and solid. A heavy fly-wheel is mounted on this shaft, to enable the governor the better to control the speed of the wheel. This fly-wheel is 14½ feet in diameter, weighs 10 tons, is made of forged iron, and has a circumferential speed of 11,400 feet per minute

The speed-gates of the wheels are plain circular rims, which throttle the discharge on the outside of the wheels. This makes a balanced gate, easy of motion. Together with the governor shown, and the fly-wheel, it is warranted by the makers to keep the speed constant, within two per cent. under ordinary conditions of operation, and not allow it to vary more than four per cent., should the work done be

suddenly increased or diminished by 25 per cent. To shut the wheel down tight, reliance is had upon the head gates leading to the penstock.

At the upper end of the main shaft is a thrust bearing, likewise shown in the drawings, to take up pressure along the shaft, in either direction—upward or downward. This pressure will, naturally, vary with the speed of the wheel, among other causes, hence a thrust bearing, thus operative in either vertical direction is a necessity. A system of water cooling is provided for this upper thrust bearing.

The plans of Escher, Wyss & Co. show twin Jonval wheels, but having their discharge from out of the wheel case in a horizontal direction, hence capable of being governed, and actually governed, by a speed gate of very much the same construction as that already described in the case of the Faesch & Piccard wheel. There is a post, or column, passing up through the wheel from the bottom of the wheel case, and an ordinary Fontaine oil bearing near the upper limit of the case. These wheels, as drawn, are submerged, and they discharge sideways from the slot in which they are to be set, instead of having the tail-race formed at the bottom of the slot and directly under the row of wheels set on beams spanning the slot, as is the case for the turbines now under contract. By placing the governor near the level of the water in the tail-race, water from the penstock is obtained under pressure, and the governor can be, and is, designed to be operated by hydraulic power.

THE MINING INSTITUTE OF SCOTLAND.

By George L. Clark.

THE Mining Institute of Scotland had its origin at a meeting of colliery managers, ten in number, held at Hamilton, on January 24, 1878. The name at first agreed on was "The West of Scotland Mining Institute," but an alteration was made a year later and the present name adopted. Rules were drawn up and confirmed at the first annual meeting, held in April, 1878. The objects of the institute, as stated in the rules, are to enable its members to meet together at fixed times to discuss the means for the ventilation of mines, the running and working of mines, the prevention of accidents, and the advancement of the sciences of mining and engineering. Its members are persons practicing as colliery managers, mining, civil or mechanical engineers, and other persons connected with or interested in mining and engineering, the annual subscription being £1 1s. or 10s. 6d. according to grade of profession.

The president for the first year was Mr. Gilbert B. Begg, mining engineer. The transactions of that year were not printed, but at each of the meetings, which were held monthly, papers on important practical subjects were read.

When the second annual meeting was held in April, 1879, the membership had reached forty-six and it was resolved to print the transactions. At that meeting Mr. Ralph Moore, then inspector of mines for the eastern district of Scotland, was appointed president, which post he held for four years and did much to advance the interests of the institute.

At the close of the second year the members numbered 205. There has been a steady increase each year since, and the number now, at the end of the fourteenth year, is 505.

JAMES BARROWMAN, SECRETARY OF THE MINING INSTITUTE OF SCOTLAND.

ARCHIBALD BLYTH, TREASURER OF THE MINING INSTITUTE OF SCOTLAND.

The presidents succeeding Mr. Moore were, for 1883-4, Mr. James McCreath, mining engineer, Glasgow, principal partner of the firm of McCreath & Stevenson, who have the largest practice in the profession in Scotland ; for 1885-7, Mr. James S. Dixon, mining engineer, Glasgow, and managing director of the Bent Colliery Company, Limited ; for 1888-90, Mr. John M. Ronaldson, inspector of mines for the western district of Scotland ; and the present president is Mr. J. B. Atkinson, Mr. Moore's successor as inspector of mines for the eastern district of Scotland, and who is joint author with his brother of a recent important work on "Explosions in Coal Mines," with special reference to the influence of coal-dust.

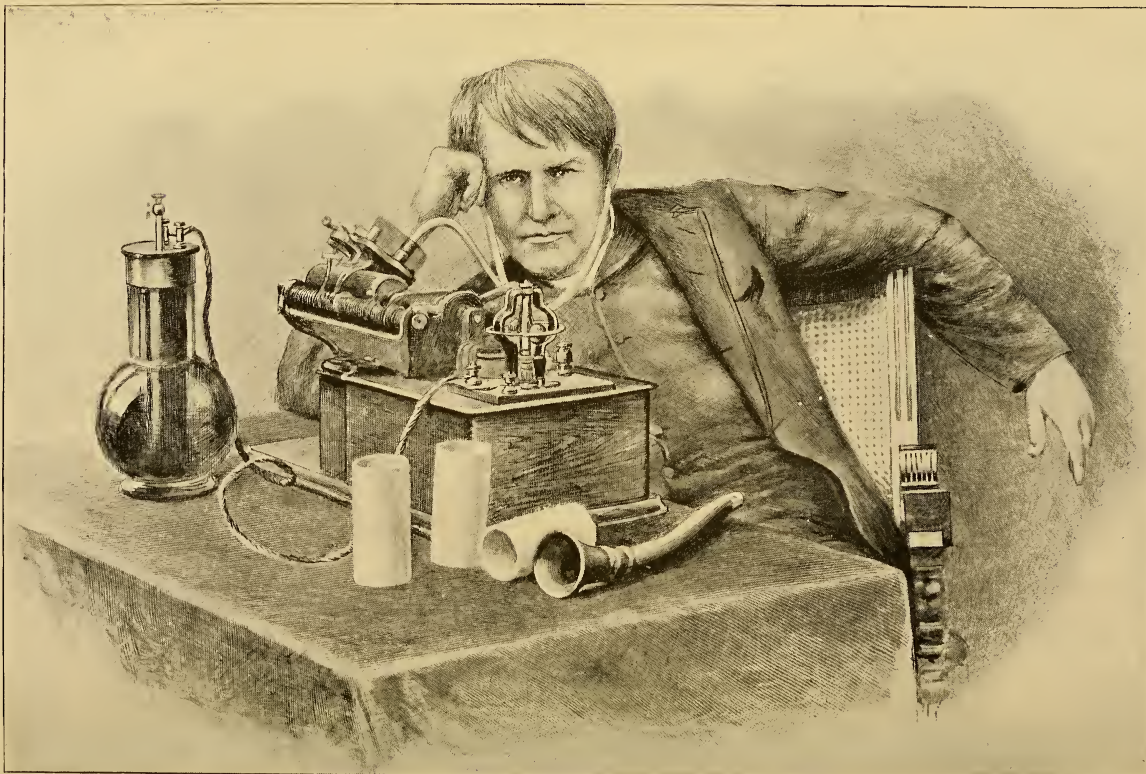
The secretary, who has held the appointment since 1883, is Mr. James Barrowman, mining engineer and mineral factor to the Duke of Hamilton, who owns the richest coal-fields in Scotland. The treasurer is Mr. Archibald Blyth, manager of the Bent Colliery Company's Bent and Hamilton Palace collieries, and one of the original founders of the institute.

The institute has no building of its own, the central meeting-place being a hired hall in Hamilton, situated in a prominent situation at the New Cross and opposite the Town Hall. The meetings, which are held at intervals of six weeks throughout the year, are not confined to Hamilton, but take place at other mining centres to suit the convenience of members.

In addition to the usual papers and discussions thereon which are printed in the transactions, now running the thirteenth volume, there have been published important reports by committees of the institute. The two most notable of these are, a report issued in 1881 on modes of supporting the roof and sides of the workings of collieries in England and Scotland, prepared by a deputation of members who visited all the collieries referred to in the report ; and, quite recently, a report on coal cleaning, prepared in a similar manner. There has also been published by the institute a glossary of Scotch mining terms compiled by the secretary, Mr. Barrowman.

An exhibition of mining machinery and appliances, held in Glasgow in 1885 under the auspices of the institute, was not the least important of its undertakings.

There can be no doubt that the Mining Institute of Scotland has done good work in bringing under the notice of mining men the newest and best results of mining practice in Scotland and elsewhere, and inasmuch as the majority of its members are those who have the immediate charge of mines, the information given by the institute and published in its transactions finds its way in a direct manner to where it is available for being put to the test of practice in the varying circumstances incident to the working of mines.



DRAWN BY R. F. OUTCALT

AFTER A PHOTO BY W. K. L. DICKSON

EDISON LISTENING TO THE PHONOGRAPH.

CASSIER'S MAGAZINE.

VOL. III. APRIL, 1893. No. 18.

NATURAL GAS AND OIL PRODUCTION.

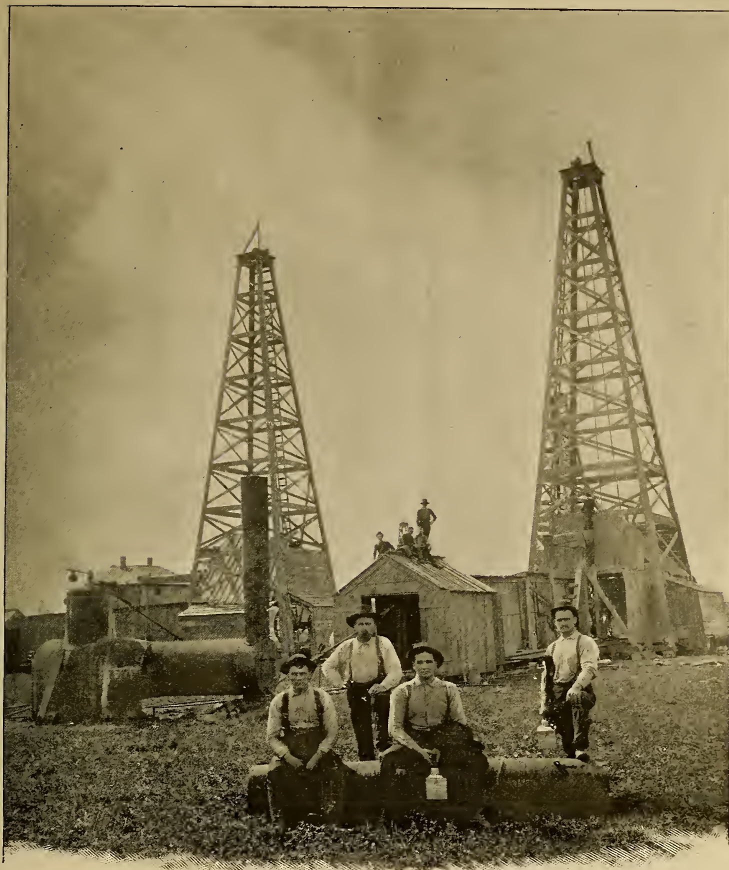
By S. D. Prentice.

THE vast industry employing hundreds of millions of capital which under the general head of "Oil production" has grown up mainly in the States of New York, Pennsylvania, Ohio, Indiana and West Virginia, although covering a total area of less than half of the smallest of these States, has become of world-wide importance, and the refined oil finds a constantly increasing demand in the principal markets of the world. The knowledge of petroleum is almost as old as history, it being mentioned in the earliest records of the Chinese, as well as by Herodotus and Pliny, and Dioscorides described the oil of Agrigentum which was used in lamps under the name of Sicilian oil. Its production as an important industry, however, is a comparatively recent event, the first well sunk for the especial purpose of obtaining oil having been drilled in 1859. This well was an Oil Creek a few miles below the present city of Titusville, Pennsylvania, and was drilled under the direction of Col. E. L. Drake. His success was almost miraculous, for he "struck oil" at a depth from the surface of only sixty-seven feet and but thirty-three feet in the rock, the drill (fortunately for him, and perhaps the future of this great industry) striking a seam in the rock through which the oil had forced its way up from the oil bearing strata some 1400 feet below, this well being in what was known as 1500 feet territory. It is said that he was on the point of abandoning the enterprise as his means were exhausted, having met with unexpected difficulties and expenses, being greatly retarded with quicksand and water. He finally drove an iron pipe from the surface to the solid rock which effectualy excluded both of these impediments. Driving this pipe, now called "Drive pipe," has since become the almost universal practice in drilling oil wells.

The success of this enterprise was quickly followed by the drilling of other wells, first in the valley of Oil Creek, and gradually extending over the surrounding territory. Test wells, or, "wild cat wells," as they were generally called, were put down in many new localities with many new and valuable finds. Among the earlier developments were the Butler and Clarion fields of great richness, and later the Bradford field which for uniform productiveness has had as yet no equal, there being no unproductive wells in a territory covering many miles in extent. A brief description of the present processes of drilling a well will no doubt be found interesting, "The rig" consists of the derrick, engine-house and

cable sheds. The working outfit consists of one reversible fifteen horse-power engine, "a string of tools" including one auger stem which is thirty-two to forty feet long, of three and one-half inches round iron and terminating in a segment of a cone shaped screw two and one-half inches at its base (the upper end), and one and one-half inches at the bottom, five inches long. There is a one-half inch shoulder at the base and the workmanship must be so perfect that when the drill is screwed home the threads must come tight at the precise point that the shoulders strike. The drill is of steel, five feet long, and for the upper eight inches is of the same diameter as the stem with hollow screw to fit that of the stem. It is flattened below to about two and one-half inches, and terminated in a drill bit, V-shaped, and of such width as the desired diameter of the well where it is to be used. The weight of a string of tools is about one ton. The weight of the cable, which is of two inches diameter and in the Ohio field, where the usual depth is about 1200 feet, is 1350 feet in length, is also one ton. The sand line, which is three-quarter inch rope the same length, is used to work the sand pump in removing from the well water and the pulverized rock. There is a blacksmith shop, and tools for "dressing" the bits when dulled by use. Enormous wrenches for removing and putting on the drills, as they cannot be sharpened without detaching them from the stem, and many other special tools

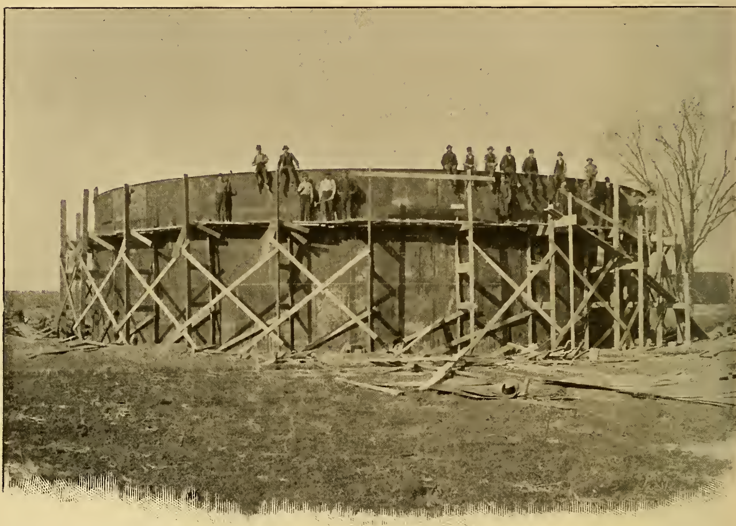
SHOOTING IN AN OIL WELL.



AN OIL WELL OUTFIT.

too numerous to describe. The illustration on this page shows very nearly a correct type of all the wells in the oil field. In the foreground is the boiler, about 150 feet removed from the engine house, to which steam is conveyed through an iron pipe packed in sawdust and enclosed in the wooden box shown in the engraving. The engine is generally placed about fifty feet from the derrick. Two pine oil tanks are shown in front of the derrick; they are eight feet high, and hold 250 barrels each, a barrel of oil being forty-two gallons. Apparently over the shed, but really just beyond it, is the walking beam, one end of which is attached to the crank shaft. On the other end, by means of a "temper screw," is firmly clamped the cable, to which the tools are attached. The tools are then lowered till they strike the bottom with

the walking beam down. They are then raised till they just clear. The clamp, is again tightened on the cable and the engine started, and the work of drilling begins. The play of the beam is usually from two to three feet, but as there is considerable elasticity to the rope the play of the tools is much more, often reaching six to eight feet, when most of the cable is in use, as is the case when the well is nearing completion. The cable is wound on a large reel, called the "Bull wheel," the end passed over a pulley in the top of the derrick, and is then brought down and attached to the tools and walking beam as above described, leaving a quantity of slack cable above the beam. The temper screw is about five feet in length, and is turned round and round lowering the tools as the drill works its way downward. Though the temper screw is but five feet in length, owing to the elasticity of the cable, six, and even eight feet of depth is often made with one screw. When the drill no longer strikes with sufficient force to do good work, the cable is detached from the walking beam, the belt connecting the bull wheel with the engine thrown on, and by means of the pulley in the top of the derrick the tools are rapidly drawn up and suspended in the derrick. A smaller reel, on which the sand line is wound, is now used to lower the bailer, which is a piece of gas pipe four and one-half inches in diameter, from ten to twenty feet long, with a valve in the bottom opening inward, and a looped iron rod riveted to the top, to which the sand line is attached. The weight of this tube is usually sufficient to sink it into the pasty substance at the bottom, formed by the mixing of the drillings with the water, which is always kept in the well for this purpose. The trip of the bailer down and back is made literally at railroad speed, for when the well is 1000 feet deep, but little, if any, over a minute is occupied in the trip.



A THIRTY-FIVE THOUSAND BARREL OIL TANK IN COURSE OF CONSTRUCTION.

IN THE HEART OF THE OIL FIELDS.

When the drillings are of such a nature that the bailer will not sink and fill, the sand pump is used. This is of similar construction, though shorter, and having a plunger, by means of which the sand is sucked in as the pump sinks.

In the Ohio field, slate rock impervious to water is struck at about 600 feet. The well is then cased, this being done by lowering sections of six-inch gas pipe, which are screwed firmly together, joint after joint, as they are put in, until the bottom is reached. The well is now cased from a few feet above the surface of the ground to the slate rock. The drillings which have adhered to the sides of the well are carried down by the dripping water settling around the casing, and packing it entirely water and gas tight. The drill used is now reduced to 5⅝-inch in diameter, and the work proceeds till completed. This is usually (where no accident occurs to delay) in about two weeks. But there are many accidents which result in a "fishing job," as it is called, which may delay progress for a long time. The drill is sometimes lost in the bottom by becoming unscrewed. It may strike a seam in the rock and be driven into it so firmly that the cable is broken in the attempt to draw it out. The casing in lowering may get away from the holder and drop to the bottom. Any of these occurrences and many others may cause a delay that will last for months, but a well is seldom abandoned from any of these causes.

When a well is about to be "drilled in," if it is expected to be a great well, the driller is usually forewarned, the drill is stopped, and if it be in new territory it is made a "mystery." A guard is placed around and no one is allowed to approach it. Parties are sent out to lease surrounding territory and the well is held back until such leases as can be had are obtained, when the well is completed. Many of the great wells for a time flow through the casing, thus carrying up a stream of oil 5⅝-inch in diameter. Where the pressure is from 400 to 800 pounds per inch, as is sometimes the case, the velocity is so high and the amount of oil delivered so great that it is impossible to save it and vast quantities of it flow down the water-courses and is lost. The first great well opened up in the McDonald field, Washington county, Pa., after wasting many thousands of barrels before tankage could be supplied, is said to have filled two 35,-

000 barrel tanks in three days. The average well, however, does not furnish oil in such abundance as to flow through so large a pipe as the casing, hence when the well is completed, and "shot," it is tubed by putting down a two-inch gas pipe in the same manner as the casing was done above described, except that the lower joint of the pipe is perforated with holes to admit the oil, and at a point above the oil-bearing strata a flange is firmly fixed an inch below the top of the joint. On the bottom of the joint above is a similarly arranged flange and between these is a rubber packing, which consists of a tube of soft rubber, five inches in diameter, eight inches long and having a two-inch hole through its centre. The weight of the pipe above resting wholly on this packing compresses it between the two flanges and swells it out laterally till it is pressed against the sides of the well with such force as to wholly prevent the gas or oil from being forced by it. The oil is thus forced into the perforated pipe and thence through the tubing into the oil tanks.

Most oil and gas wells require "shooting" before they are at their best. The shot is usually from twenty to eighty quarts of nitro-glycerine, but sometimes as high as 150 quarts are used. The process is quite simple. Long tin cans filled with the fluid, are lowered into the well and then carefully let down to the bottom, the well having been previously filled from one-half to two-thirds full of water. The cans are left open and sink through the water, but the glycerine retains its place, as it is heavier than water. At the upper end of the last tube and about a foot from the top a bar is soldered across the inside, on which a small tin tube is fastened, which extends to the top of the can. Upon each end of a short piece of wire, which is a little smaller than the tube is placed a common waterproof gun cap, and this is dropped into the small tube. A second piece of wire and sometimes a third are capped and put on top of the first, the last piece extending an inch above the can, which is also capped, and the whole is lowered on to the other cans. All is now ready for the shot. The spectators get away. The well-shooter lets go the "go-devil" (a piece of iron weighing five or six pounds, and of proper shape to make it sure that it

THE GREAT KARG GAS WELL AT FINDLAY, OHIO, WHICH YIELDED THIRTY MILLION FEET OF GAS DAILY WHEN FIRST OPENED.

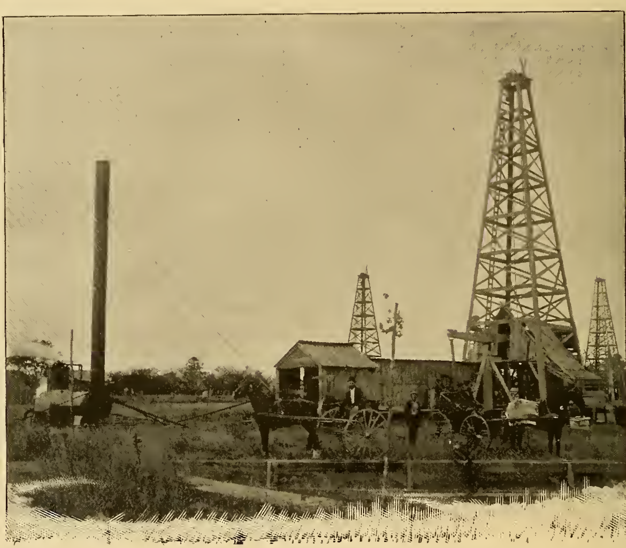
must strike the rod in the centre of the well), and runs back perhaps a hundred feet. A half minute elapses and a slight shock is felt. A minute more, and the water begins to rise above the casing. Higher and swifter it ascends till it breaks into spray far above the top of the derrick. Stones rattle through the derrick, and the oil falls in a shower of greasy spray. The spectators must be on the windward side or they might be covered with oil. Before the shot all fires in the vicinity are extinguished, as many wells have been ignited by fire under the boiler a hundred or more feet away. All flowing wells are the result of gas pressure, and when the gas becomes exhausted they cease to flow and are then known as "pumpers." When a well can no longer be made to flow, if the amount of oil which it produces is believed to be sufficient to warrant the expense it is arranged with a number of others to be pumped. One boiler usually furnishes the steam, and one man can do the work required to pump a number of wells, sometimes as many as eight or ten, but more commonly from three to six; an engine is, however, required at each well, but steam is conveyed (from a boiler centrally located) by pipes to each engine. Few wells have to be pumped steadily; generally the oil is allowed to accumulate in the well, and is then pumped out, the frequency of such pumping depending, of course, on the rapidity with which it comes into the well. When the tank is full the pipe line company is notified, the tank is gauged, the pipes connecting it with the pipe line's pump station (which may be several miles away) opened, the pump started, and the oil is quickly in one of the company's great iron 35,000 barrel tanks. All pipe lines take all the oil produced by wells with which they are connected at their quoted prices, and at their own expense lay new lines to all producing wells in

AN OIL TANK IN A PICTURESQUE LOCALITY.

their range of territory as soon as the wells are supplied with tankage.

Nearly all the oil at present produced is sent through pipe lines to the great refineries, which are located in various cities. At Cleveland, Ohio, probably more oil is refined than at any other locality. To this city the pipe lines of the Standard Oil Company run from both the Pennsylvania and Ohio fields. There are also two lines from the Ohio field to Chicago, one of eight-inch pipe, and one six-inch. The capacity of the eight-inch line is 30,000 barrels per day. The oil is forced by great pumps of special construction for this purpose from a single pump station the whole distance to Chicago. Much of this oil is used in the crude state for fuel purposes in the great factories, the Chicago Rolling Mills taking for this purpose 1200 barrels of forty-two gallons each daily.

The cost of a well, including cost of all machinery and tools, rig, and tanks, in 1200 feet territory, is about $3500. Wells are drilled by those in the business 1200 or 1500 feet deep for about $1 per foot. Different localities in even productive territory vary greatly in the amount of production, single wells being sometimes a fortune to the lucky owner. In the McDonald field (Washington county, Pa.), still one of the best, though greatly less than last year, the production of new wells was as follows: thirty-nine were completed in the month of October, 1892, which yielded daily 2908 barrels, in November twenty-three new wells averaged 101 barrels each daily. In Sisterville 287 old and new wells in the month of January, 1893, produced 18,000 barrels, an average of sixty-two barrels per well daily for all wells, old and new. The highest average pipe line daily shipments for a single month were for the month of November, 1891, being 135,314 barrels. For the same month, 1892, 84,264 barrels,



INSPECTING A NEW WELL.

the average for the year being a few thousand barrels higher. The highest quotations recorded since 1860 were in January of that year, when the price went up to $20 per barrel, yet in December of the same year it was quoted at $2. The lowest quotations were in November, 1861, and January, 1862, ten cents. The lowest since January, 1868, was in July 18, 1882, 49¼ cents, and December, 1874, forty-five cents. Though the Ohio oil was steadily quoted at fifteen cents per barrel for over four years, the Standard Oil Company claiming inability to refine it, the price for this oil is now forty-five cents. All statements above given the writer is confident may be relied upon as absolutely correct. The facts upon which they are based have been obtained (when not within the personal knowledge of the writer) from men prominent in the departments from which information was desired, and hence are wholly trustworthy. From these facts the reader will be able to form an approximate estimate of the part oil and gas are now taking in the productive industries of the world. Only the third of a century has passed since Drake drilled the first well for oil. The business is in its infancy. The vast mountain ranges of the world—the natural depositories of this fluid—are as yet unvexed by the drill of the oil operator. What they hold in store for the future can only be imagined, but that oil and natural gas are to be the source of the world's great fuel supply in the future seems from known facts to be altogether probable. That they have also been the source from which the great coal deposits of the world have had their origin the writer believes, and confidently hopes that the facts which he is able to present will, in the mind of the thoughtful and unbiased reader, justify his claim. The writer further believes that natural gas pressure is the general source of those remarkable changes in the earth's surface known as seismic phenomena, including volcanoes, earthquakes, tidal waves, hot springs, and the upheaval of mountain ranges. But this latter subject will be reserved for a future article. In Encyclopædia Britannica, vol. 18, page 727, is the following: "Petroleum is one of the most widely distributed substances in nature, but an examination of the geographical locations in which it chiefly occurs will show them to be intimately connected with the principal mountain chains of the world. * * * Petroleum occurs in all geological formations from the Silurian up to the Tertiary."

It is the influence of this vast product of nature, perhaps almost as old and widely extended as the earth itself, a product although so recently almost unknown, is now competing successfully as a fuel with coal, the reader is asked to consider in its relation to seismic phenomena and coal formation. Conservative thought is at once in arms when it is attempted to replace the teachings of the books with new ideas and new explanations of phenomena which they have claimed to explain, how faulty soever such explanation may be, and the writer does not anticipate escaping without his share of such criticism. But believing the facts which he is able to present will be his best defense, he will at once proceed to place them as concisely as is consistent with clearness before the reader.

1st. Coal formation. Had the present amount of knowledge in regard to the gas and oil deposits of the world existed prior to the publication of the theories explanatory of their formation, it is not probable that the world would have ever heard of the vast primeval forests of gigantic growth which seem to have been only hypothecated to account for the coal beds, as there is absolutely no proof that such forests ever existed except in the imaginations of those who used them for this purpose. To those who have examined the geological formation of the coal fields and seen stratas of coal varying from only an inch in thickness to many feet, it must seem impossible that such strata could be laid down out of the products of gigantic forest trees by any possible natural process except that of rotting, and rotten wood could not

possibly form coal. The drift wood carried down by great rivers might form deposits in quantities sufficient to form coal beds, but such deposits would be crossed and piled in all conceivable shapes, and would be soon filled in between the logs and limbs with earthly matter which could not possibly make coal—would render a strata of uniform thickness impossible even though coal were formed. But wood coal formed by burning wood where the air is mostly excluded, has properties so distinctly dissimilar from natural coal as to almost exclude the possible supposition of their similar origin. The wood coal shows the grains of the wood clearer than before it was burned. Wood coal is light, it burns with little smoke, it never melts in the process of combustion, its little smoke is blue. None of these things are true of natural coal, which shows no grains, but is formed in stratas showing that if not itself a fluid when deposited, it must at least have been laid down as a fluid deposit. Most natural coals melt to some extent in the process of combustion. They give off when burning a dense black smoke in appearance identical with that of burning oil, and having the same sulphurous odor. Their soot is a lamp-black, identical with that produced from burning oil or gas, a substance not producible from wood, but only from the pitch of resinous woods, and even this is quite different in some of its properties. As is known, first refined oil made for illuminating purposes was distilled from coal and called coal oil. This oil was identical in odor, color, density and all observable properties with the oil now distilled from the crude petroleum. It is not possible to distill this oil or one approximately identical from any known wood. The nearest approach to it being the spirits of turpentine, and this is from the pitch and not from the wood fibre. It is clearly unscientific and illogical to claim that a substance which cannot be shown to exist in wood may be distilled in a large per cent. from the residuum of wood which coal must be if it be the product of wood at all. The above is principally the presentation of the negative view of this subject. The affirmative is certainly not less conclusive when standing alone, and when supported by the above seems to the writer to render further doubt as to the correctness of his theory of the formation of coal from rock oil instead of wood fibre unreasonable.

The writer will undertake to trace the formation of coal from the crude oil as it is now progressing within the range of human observation. The great and well-known asphaltic lake in the Island of Trinidad, which covers ninety acres of surface and is of unknown depth, has four oil springs in constant flow. These springs have furnished the material of which the lake is at present composed, which is of every grade of density from that of the crude oil at the springs to the hard asphalt of commerce. That this asphalt has been formed by the simple process of drying down in the sun's rays, the oil produced by these springs, there is and can be little doubt, for from the shore outward to these oil springs is found every grade of density from the hard asphalt to oil.

But, says the objector, asphalt is not coal. True, but in this evolution theory there is no lost link. In the mountains of Navada there are now marked asphalt mines of both the red and black asphalt. These mines when found were supposed to be coal and lignite, but when placed upon the fire it was found that they melted down and hence were only asphalt. They are very pure or free from dirt, and are quite extensively used for roofing paints and for painting iron, for which purposes they are much superior to coal tar, which they have largely displaced for these purposes. The next link is the cannel coal, when lighted and held upright will slowly melt, burning as it melts, the only apparent difference between this coal and the Navada asphalt being the somewhat lower temperature at which the latter melts. Each of these substances gives off when burning the same dense black smoke, having a similar odor, showing as the only difference that the coal has dried down into a harder sub-

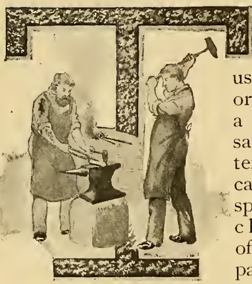
stance, is in fact simply an older formation. Bituminous coal also melts to some extent before burning. Neither the fibre of any known kind of wood, the wood itself or any product of wood (except resinous gums, which never form wood), will do this. True, the anthracite coal does not melt and gives off little smoke when burning. It has probably had its smoke driven off by heat during its formation and is doubtless the oldest of all the coal formations.

If scientists accept as possible the statement or theory that both anthracite and bituminous coals as well as lignite have been the result of enormous growths of timber in primeval forests, they cannot consistently refuse to accept as a fact that they are the product of gas and oil on the proofs presented, for there is a much wider difference between these different kinds of coal than between some of these coals and asphalt, and the latter is undisputably the product of oil, as observations on the asphaltic lake at Trinidad clearly prove. There is no missing link over which the advocates of the wood theory have not stepped without question ; they cannot consistently stop to cavil now.

Natural gas probably has had more to do with the superstitions of the past than any other product of nature. The vast quantities in which it exists in the earth, the enormous pressures under which it is stored away in the seams and fissures of the rocks, as well as in the porous rocks themselves, often causing the cracking of the overlaying rocks with a power that shakes the solid earth, the opening of a seam from which proceeds a great fire apparently without fuel, the setting fire to a river by the ignition of oil upon its surface, the bellowing of the escaping gas where fissures have been rent, may well have been a prolific source of superstition and terror to the ignorant. The source of the production of the vast quantities of natural gas known to exist is as yet an unsolved problem, but that there is abundance for the entire world's fuel supply seems beyond question. The great Karg well at Findlay, O., when first struck, was estimated to yield 30,000,000 feet daily before it was gotten under control. Yet this was through a casing five and five-eighths inches in diameter. At one of the eruptions of Etna a crack opened along its base twelve miles long and six feet wide through which the gas rushed with such force that its roaring could be heard forty miles ; this continued for a long time. When we remember that this distance is about the greatest at which the heaviest cannonading can be heard and compare by figures this crack with a five and five-eighths inch round pipe furnishing 30,000,000 feet daily, we may begin to form some estimate of the possibilities of this wonderful product of nature which already controlled by the genius of man is lighting and heating with a degree of comfort and perfection never before possible to attain ; many thousands of homes in country, village and city in America, flowing by its own force in a steady stream from the bowels of the earth into stoves, furnaces and grates, ever ready without preparation or notice, at a simple turn of the throttle, to burst into a blaze, great or small as may be desired at the touch of a match, the most perfect conservator of human comfort yet utilized by man. That this subject is worthy a more careful scientific investigation than it has yet been accorded the writer believes, and it has been with the view to contribute somewhat to such investigation that this article has been written.

MACHINE KEYS.

By John Richards, M. E., Editor of "Industry."



THERE appears at intervals, usually of three or four years, a series of essays and letters in technical journals respecting machine keys, often accompanied by rules or formulæ for proportions and analysis of the strains or pressure on key surfaces and the seats in which they fit.

This literature does not seem to have much effect on practice, and this is not to be wondered at, because in nearly all cases, and indeed all of recent date we have seen, the subject is treated "generally," and without recognition of the fact that there are two kinds or systems of keys, both proper and necessary, but widely different in nature, and it may be suggested that a failure to make this distinction is a main cause of divergent opinions and practice.

The two kinds of keys referred to are illustrated in the diagrams Figs. 1 and 2. Fig. 1 shows the common fastening key, usually made in width one-fourth of the shaft's diameter, and the depth five-eighths to one-third the width. These keys are tapered and fit on all sides, or, as it is commonly described, "bear all over." They perform the double function in most cases of driving or transmitting and fastening the keyed-on member against movement endwise on the shaft. Such keys, when properly made, drive as a strut, diagonally from corner to corner, in the direction indicated by the arrows, a fact not always considered or understood by those who fit them.

The other kind or class of keys, shown in Fig. 2, are not tapered and fit on their sides only, a slight clearance being left on the back at *a* to insure against wedge action or radial strain. These keys drive by shearing strain as indicated by the arrow, and consequently in a totally different manner from those shown in Fig. 1. For fixed work where there is no sliding movement such keys are commonly made of square section, the sides only being planed, so the depth is more than the width by so much as is cut away in finishing or fitting, as shown in Table II.

For sliding bearings, as in the case of drilling-machine spindles, the depth should be increased, and in cases where there is heavy strain there should be two keys or feathers instead of one.

It was the intention at first to confine the present remarks to the application or use of these different kinds of keys, but as the question of proportions will be involved the following tables for dimensions will be of use for reference. They are taken from proportions adopted in practical use, and expressed in parts of an inch for convenience.

Referring now to use, flat keys, as in Fig. 1, they are employed for fixed work when, as before explained, the parts are to be held not only against torsional strain but also against movement endwise, and in case of heavy strain, the strut principle being the strongest and most secure against movement when there is strain each way, as in the case of engine cranks and first movers generally. The objections to the system for general use are, straining the work out of truth, the care and expense required in fitting, and destroying the evidence of good or bad fitting of the keyed joint. These objections are, of course, not to be considered when such keys are re-

quired, but only in respect to limits of their application.

When a wheel or other part is fastened with a tapering key of this kind there is no means of knowing whether the work is well fitted or not. The wedging action on the back of the key holds all firm, and the only evidence of bad fitting is in a want of truth in the movement of the member keyed on. For this reason such keys are not employed by machine-tool makers, or in the case of accurate work of any kind, indeed cannot be, because of the wedging strain, and also the difficulty of inspecting completed work. In the Industrial Works at Philadelphia, now Bement, Miles & Co., it was the custom formerly, and may be now, for the inspector to insert a thin strip of metal on the back of the key at *a*, Fig. 2, to see if there was a bearing there so as to hide bad fitting. If there was no bearing then the work could be started off or sidewise with a blow, unless it was a "pressed-on" joint. In that case there was always other evidence to show the fit. The same rule applies in England to general practice, especially to machine tools and similar work, and, as explained, is a necessity in successful inspection, as well as in all cases where parts have to be removed or interchanged, like the train wheels

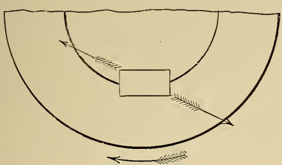


FIG. I.

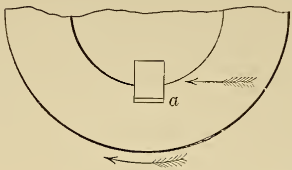


FIG 2.

I.

DIMENSIONS OF FLAT KEYS, IN INCHES.

Diam. of Shaft..	1	1¼	1½	1¾	2	2½	3	3½	4	5	6	7	8
Breadth of Keys.	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1	1⅛	1⅜	1½	1¾
Depth of Keys..	5/32	3/16	¼	9/32	5/16	⅜	7/16	½	⅝	11/16	13/16	⅞	1

II.

DIMENSIONS OF SQUARE KEYS, IN INCHES.

Diam. of Shaft......	1	1¼	1½	1¾	2	2½	3	3½	4
Breadth of Keys....	5/32	7/32	9/32	11/32	13/32	15/32	17/32	9/16	11/16
Depth of Keys......	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	¾

III.

DIMENSIONS OF SLIDING FEATHER KEYS, IN INCHES.

Diameter of Shaft.....	1¼	1½	1¾	2	2¼	2½	3	3½	4	4½
Breadth of Keys.......	¼	¼	5/16	5/16	⅜	⅜	½	9/16	9/16	⅝
Depth of Keys..........	⅜	⅜	7/16	7/16	½	½	⅝	¾	¾	⅞

of engine lathes. In miscellaneous practice it is easy to see that two kinds of keys are required, and any useful dissertation on the subject must recognize and embrace this fact. In some cases flat keying will be most required, in steam engine making and mill gearing for example. In other cases where the lighter class of machinery is made, nine-tenths of the keys should be of the shearing class, shown in Fig. 2, and are so made.

Compression couplings of all kinds are fastened by this kind of keys, and must be. A wedge key bearing radially would be a contradiction of the clamping feature of such couplings.

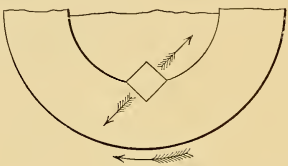


FIG. 3.

On the contrary, flange couplings are fastened with flat or strut keys to hold against end movement.

Sliding keys, called sometimes "feathers" or "splines," such as are moved under strain, require more bearing surface or depth as given in Table III. Such surface can be gained by length in most cases, or by two keys, one on each side, which is preferable because of dividing the torsional strain, and preventing wear of the main bearings on one side. It is only recommending good practice to claim that every traversing spindle or shaft operating under strain should have two keys or feathers. The extra cost is not much, and the advantages are obvious, especially for screw cutting and boring spindles of machine tools.

These remarks are called out at this time by observing some articles on the subject in several technical journals, and especially by noting in a drawing of the Ball & Wood steam engines, keys as shown in Fig. 3. This seems a novel method, and is certainly one that has claims in respect to adaptation and economy for fixed joints. The key drives as a strut, in the manner indicated by the arrows, and certainly seems an improvement on the flat key system. The bearing surfaces in proportion to cross section are increased. Key-ways of moderate size for shafts, four inches or less in diameter, can be made at a single cut with milling cutters or gauge tools ground to an angle of forty-five degrees, or for larger keys by planing to the same angle each way, the only care required being to attain a definite width at the top or surface. Cutting in these angular grooves is much more free than in planing out rectangular ones, and there is not that unavoidable wear of the "corners" of the tools, be they for planing or milling. There is an impediment in the way of taper, when required, but we imagine that with keys of the kind, taper can be dispensed with if the fitting is well done.

THE MODERN TRAVELING CRANE.*

By Alexander E. Outerbridge, Jr.

THE readers of this article are composed so largely of gentlemen who are engaged in mechanical pursuits and familiar with mechanical devices that it would seem almost superfluous to tell them that the problem which has confronted the modern manufacturer in his effort to produce larger machines of various kinds than heretofore—heavier locomotives, bigger bridges, more powerful war ships and the thousands of other gigantic structures demanded in this era of mechanical progress—has been, not so much a question of the enlargement of factory buildings, or of increasing the melting capacity of furnaces, or of adding to the number of employees, but it has been mainly a question of obtaining adequate facilities for handling quickly and economically the enormously heavy materials composing such great structures, and I do not think it is an exaggeration to say that the limit of capacity of any establishment for such large work is practicaly determined by its facilities for handling its raw material with economy and despatch.

If you are given unlimited time and an unlimited amount of labor you can accomplish great results, with exceedingly simple and crude appliances, but the more you try to economize time and labor in the performance of mechanical work, the more intelligence and skill you must crystallize into your auxiliary machinery.

We all know that the simple dropping of water will, in time, wear away the hardest stone, but the little rock drill, which performs its work in a few moments, represents a high degree of mechanical efficiency.

The old-fashioned cumbersome jib-crane, slow of motion and limited in scope to the swing of its clumsy arm, so long a prominent eye-sore on the floor of every foundry and machine shop, is gradually disappearing, and is being superseded in progressive establishments by what may be called the rapid transit elevated railway traveling crane, occupying no floor space and limited in range only by the walls of the building in which it operates. While this modern economical and expeditious method of handling heavy merchandise may still be regarded as a novelty, it has passed the experimental stage and the mechanism has already reached a degree of perfection which leaves little to be desired in respect to speed, safety, simplicity and accuracy of operation. This is the result of much study, costly experiment and practical experience.

The elevated railway traveling crane consists of four essential parts:

(1) The elevated tracks.

(2) The traveling bridge.

(3) The trolley car traversing the bridge and carrying the hoisting mechanism.

(4) The motor or driving mechanism.

Two independent elevated tracks, with in some types parallel toothed racks bolted thereto, are supported by iron columns (or, in the case of a new building specially constructed, built in and supported from the walls), which run parallel to and close to the walls from one end of the building to the other. The bridge travels upon this runway propelled by positive gearing engaging with the racks, thus insuring

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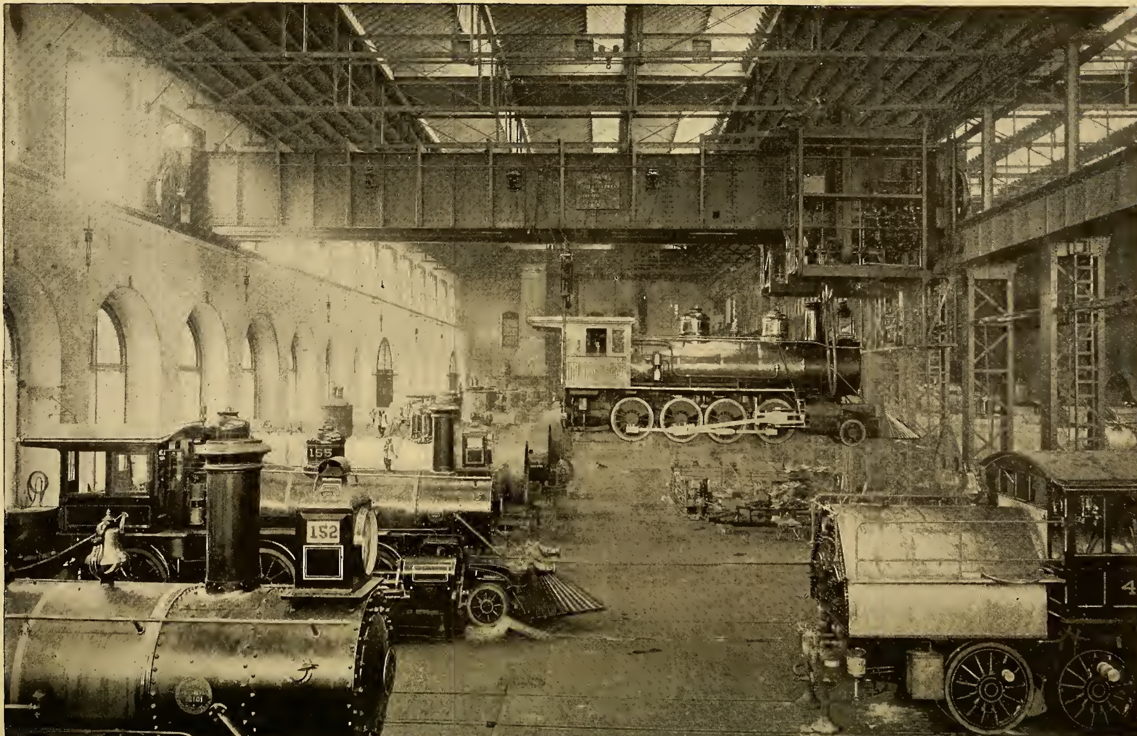


100 TON HIGH SPEED ELECTRIC TRAVELING CRANE, AT THE NEW ERECTING SHOP OF THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA. BUILT BY WILLIAM SELLERS & CO., INCORPORATED. SPAN OF BRIDGE, 74 FEET, 8 INCHES; LENGTH OF RUNWAY, 335 FEET; BRIDGE TRAVEL, PER MINUTE, LENGTHWISE, 100 AND 200 FEET; TROLLEY TRAVEL, CROSSWISE, 50 AND 100 FEET; HOISTING AND LOWERING, 5, 10, 20 AND 40 FEET.

perfect alignment under all circumstances.

The bridge is constructed of two parallel plate girders extending from rail to rail, spanning in mid-air the breadth of the building. Four large double-flanged steel-tired wheels with steel axles running in bearings are bolted to projections on the girders, a skimming clearance only being permitted between the top of the rail and the bottom of the girders.

Between the girders heavy steel tracks are laid, bolted to their lower inner flanges, upon which a trolley car, carrying the hoisting mechanism, runs back and forth ; thus, by the two motions, the longitudinal motion of the bridge and the cross-motion of the trolley every square foot of available space in the building can be covered.

The girders forming the sides of the bridge are securely tied together by angle-iron braces and the bridge is still further stiffened against lateral strains by exterior girders, extending upward and outward at a sharp angle from the bottom flanges of the bridge members and bolted to struts or braces extending across the top of the bridge. By this method of construction great rigidity is secured, while the entire space within and beneath the bridge is left unobstructed for the working of the trolley car and machinery.

The car which travels on the bridge tracks is provided with a grooved drum and depending double chain wound thereon, carrying a forged swivel hook mounted securely in a hoisting block on ball bearings, the block being furnished with sheaves through which the chain runs. The friction on the swivel is so reduced by the ball-bearings that it was found in actual trial that a load of fifty tons suspended from the hook could be easily rotated by one man.

The winding of the double chain in the grooves of the drum is always toward the centre, and this insures a perfectly vertical lift of the load, an advantage always, and a necessary feature in many instances.

The placing of the rails for the trolley on the top of the bridge, as is sometimes done, is open to serious objection on account of the tendency to produce unstable equilibrium of the bridge, or spreading of the girders, and disasters have occurred from the toppling over of the trolley when heavily loaded, due to these causes. It can readily be understood that these defects are eliminated by locating the point or support of the load on the lower inner flanges of the girders, instead of from a trolley on top of the bridge.

The racks with gearing on both ends of the bridge prevent any tendency to mount the rail or to jam on the runway and permit high speeds with safety, and even if an accident should happen to the running gear of the bridge, such as the breaking of an axle, the bridge would merely settle down half an inch and then rest upon the rail.

Retaining clutches automatically hold the load securely from the moment it leaves the floor until it is redeposited, the chain can never run down, but the load must always be pushed down by the operator moving a lever.

The operator's post is on a platform or cage supported at a convenient point under the bridge ; by simple lever movements he applies the motive-power to drive the bridge along the rails and simultaneously to drive the trolley across the bridge, so that, during the two motions at right angles, the hook depending from the chain travels in the resultant diagonal direction until it is vertically over the object to be hoisted. A simple application of power revolves the drum lowering the chain and when the object is attached a like delicate touch causes the drum to revolve in the opposite direction, winding up the chain and lifting the object to the desired height. The bridge and the trolley are again started in their respective longitudinal and cross movements, the suspended object traveling in the resultant of the two directions in a straight line from its starting point toward its destination, until vertically over the exact spot where it is to be deposited, when it is a simple matter to lower and adjust

it in place; the speed of all of these movements is under absolute control of the operator and the precision of adjustment where delicacy of movement is required, as in the setting of cores, closing of flasks, etc., is remarkable both for its perfection and for the ease with which the operation is performed. These movements may be, and frequently are, directed from below by the finger of the foreman.

Various motive-powers are applicable to operate a traveling crane; such as (1) an independent engine and boiler carried on the crane; (2) a square shaft, with tumbler bearings, bolted to the wall of the building; (3) an electric motor or motors. Each of these methods of driving the crane possesses individual peculiarities, and each offers particular advantages for special classes of work and convenient adaptation to peculiar environments.

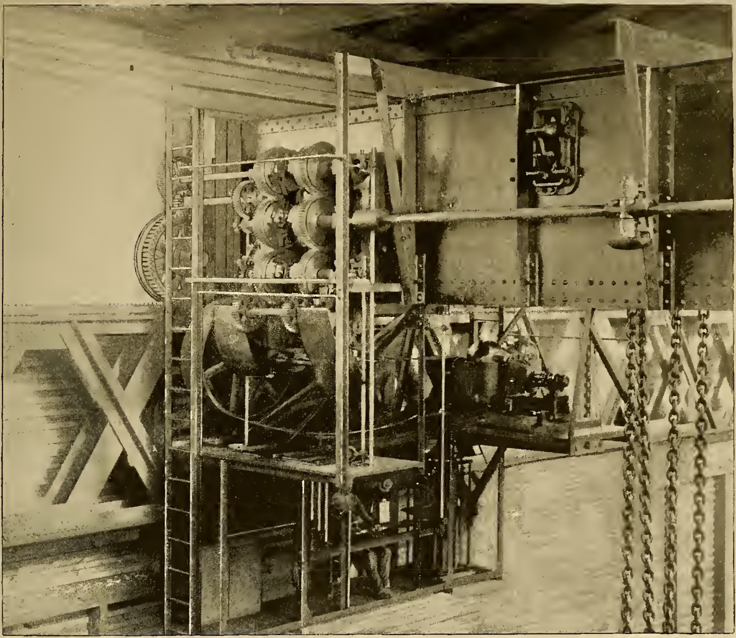
The best evidence that these distinctions are understood and appreciated, is furnished by many large establishments, such as the Baldwin Locomotive Works, where all of these types, of recent construction, may be seen in the different departments, ranging from liliputian crane of five or ten tons capacity adapted to quickly shifting a cylinder, or other portion of an engine, from place to place in its progress from the condition of a rough casting in the foundry to a finished piece in the erecting shop, to the 100-ton electric giant which picks up a completed "Mogul" or "Decapod" engine of the largest size, carrying it swiftly over the heads of the workmen and depositing it gently on a railway siding near the exit.

While we have thus shown that there are various methods applicable to driving the traveling cranes and in daily use for that purpose, many persons regard the electric current as *par excellence* the modern method, and, in accordance with the demand thus created, large electric traveling cranes, having two trolleys on the bridge and five independent motors, have been constructed and are now in operation. A speed of travel on the runway of 500 feet per minute is attained and a correspondingly quick traverse of the bridge by the trolley. These may be regarded as "lightning express" traveling cranes. The rate of travel or of hoisting is perfectly controllable from that of a snail's pace to the maximum speed, and the limit of speed is mainly a question of expenditure of power.

As a rule, a slow motion is required when the crane is hoisting and transporting heavy weights, but the more rapidly the crane can travel from a locality in the building where its work is completed to another where its help is needed, and the more rapidly it can perform the preliminary operations of attaching chains to the object to be lifted (which tedious work may be said to occupy usually about nine-tenths of the time during working hours), the more efficient the appliance becomes.

The method of operating a traveling crane by electricity forms the most novel type, and yet so rapid has been the evolution, that already several subtypes are included under this general head. When a single motor is carried on the cage the clutch system, similar to that used with the square shaft mechanism, is employed. In the three-motor or five-motor, or entirely electric crane, the clutches are discarded with the exception of one pair on the trolley.

In the electric system one or more motors on the bridge or trolley are supplied with current from a dynamo by means of an overhead wire running the length of the building. By touching a few simple levers, or hand wheels, the wheels of the bridge are caused to revolve, the trolley car itself is caused to travel back and forth on its cross tracks, and the grooved drum carrying the chain and hook is caused to rotate, raising or lowering the hook, all of these motions being performed either at the same time or separately, in the same direction or in opposite directions, at the same speed or at different speeds, fast or slow, without confusion, by one man of ordinary intelligence. The operators are usually chosen from the ranks of unskilled labor, and are soon



PART OF CRANE SHOWING TROLLEY.

taught the simple movements. The levers are so arranged that the necessary as well as natural movements of the operator are in the direction he wishes the object to go, thus relieving him of even embarrassment or uncertainty.

While this paper is designed to afford a general, or popular, yet accurate, description of the modern elevated railway traveling crane, and is sufficiently broad in its scope to cover the fundamental principles upon which all such cranes are constructed, the writer desires to point out in conclusion a few of the advantageous features which have been briefly alluded to, herewith illustrated, characterizing the cranes made by William Seller & Co., Incorporated, of Philadelphia, on which are lavished the results of indefatigable experiment, aided by extended experience in their shops, and in the manufacture and sale of cranes, covering a period of many years.

The question of safety is a factor of first importance in a machine designed to transport constantly over the heads of workmen enormously bulky and heavy materials and has formed the key-note to the design of every part of the structure, for example:

(1) the plate girders forming the bridge not only have inherently an immense reserve factor of safety, but they are tied together and strengthened by the angle-iron lattice girders on top, and by the external bracing extending from the bottom flanges to struts across the top in a manner entirely original and affording a degree of stiffness unattained heretofore. Furthermore, the maintenance of true alignment and prevention of twisting or jamming by means of the racks and gearing at each

end of the bridge relieves the girders of undue lateral strains and is peculiar to this crane.

(2) Double-flanged wheels with steel tires accurately turned to fit the head of the rail are substituted for cast-iron wheels usually employed for this purpose.

(3) Flat friction clutches with broad bearing surfaces of positive action are substituted for conical clutches usually employed and of uncertain efficiency.

(4) Automatic support of the load at all times, requiring the use of power by the operator to release the tenacious grip of the clutches and push the suspended object down.

(5) The method of supporting the ends of the girders above the rails with a skimming clearance only, so that in case of accident to the running gear the bridge merely settles upon the rail.

(6) The placing of the trolley car between the girders, instead of on top of the bridge as is customary, contributes to the stability of the entire structure and is an evidence of the careful way in which correct principles have been elucidated and applied to all details. These are but samples of the numerous safety appliances.

The ability to reach the load to be moved in the shortest possible time, whereby the preliminary operations of getting ready to lift are materially hastened, combined with the slow and steady pull, free from jar and susceptible of delicate adjustment, meets every desideratum.

While the location of all working parts upon or over the cage, within easy reach and sight, facilitating oiling, tightening of nuts, etc., by the attendant when not operating the levers ; the ease with which parts may be removed for repairs, together with the ample proportions of each individual piece in its proper relation to the whole, all tend to minimize the cost of maintenance, while the economy of power in operation has been studied with equal care with the view to make this type of crane the criterion upon which the merits of all other forms must be judged.

The traveling crane recently constructed at these works for the Columbian Exposition is an all electric crane. The bridge has a span of seventy-six feet and the runway is 1400 feet long ; there are two trolleys on the bridge, with a lifting capacity of ten tons each.

The bridge is provided with an observation platform running its entire length, and upon this platform several hundred observers can be carried from end to end of the machinery building over the exhibits and far above the heads of pedestrians. The platform which carries the passengers does not interfere with the hoisting mechanism, so that this crane may be employed to hoist and transport goods and passengers at the same time, or alternately, if desired.

The adaptability of the traveling crane to size, power and practical usefulness extends between wide limits. Cranes of the type described are in operation to-day which will transport with equal ease a complete locomotive of the largest size or a delicate sand mould without disturbing a grain of the sand.

In the foundry and machine shop it makes the entire floor space available, and it is equally applicable in the stone yards, docks, and indeed wherever heavy materials require to be moved with celerity from place to place. A single operator with a single apparatus exceeds the capabilities of a dozen stationary cranes installed within reach of each other, effecting an enormous saving in time, labor and cost. The modern traveling crane may fairly be regarded as one of the great inventions entitled to a high rank among the mechanical achievements of modern times.

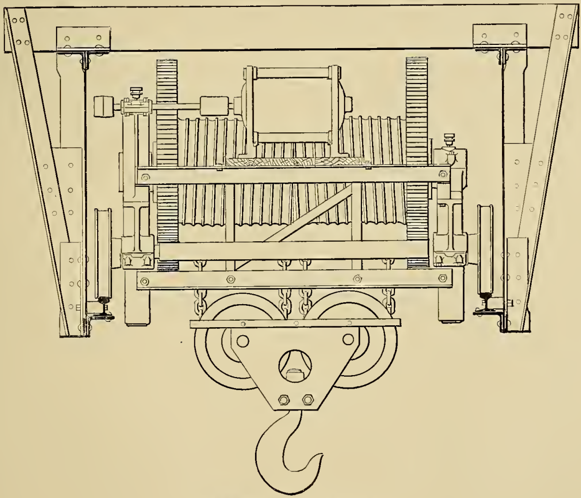
The great pyramid at Gizeh, near Cairo, erected more than 4000 years ago (or according to the generally accepted chronological records more than six centuries before the time of Moses), stands to-day the largest structure of any kind ever erected by the hand of a man ; composed of huge blocks of hewn stone, covering a space of more than thirteen acres at its base,

equivalent to more than four squares of buildings in the city, it rises to a height of more than 450 feet. The weight of this great mass has been computed at more than 5,000,000 of tons.

Modern writers are fond of pointing to these facts as evidence that the ancients possessed mechanical appliances for handling heavy materials far surpassing those of the present time, but, until the two important factors of time and of labor are more clearly stated, I think we are justified in withholding our assent to such a broad inference. What did those autocratic rulers of Egypt care whether 100 or 1000, or 100,000 slaves were employed for a year or a decade, or a century in the construction of this great monument? They were building for all time, and had no thought of economy of time or of labor in the construction.

The Greek historian Herodotus, who visited this pyramid about 400 years before the Christian era, tells us that it was regarded in his day as the most stupendous and most venerable monument of antiquity, and he further states that certain inscriptions on stone tablets recorded the fact that 100,000 men were engaged for thirty years in its construction. I have little doubt that if such a problem should be presented to our modern engineers it could be solved with the expenditure of a fraction of the time and labor represented in this great pyramid.

Coming now to a more modern illustration for the purpose of our comparison, I am reminded of an amusing story related of the late Matthias W. Baldwin in the early days of his locomotive building in Philadelphia. The incident occurred, I believe, about the year 1840. One morning Mr. Baldwin received in his mail an order for twenty locomotives, coupled with the condition that they must be completed and ready for delivery within one year of the date of signing the contract. Mr. Baldwin declared that such a proviso with such a large order was preposterous, and that it would be impossible to complete the contract in the time specified. On looking over the illustrated history of the Baldwin Locomo-



CROSS SECTION OF TROLLEY.

tive Works I find that the total output for the year 1840 was nine engines, and it was not until thirty years had elapsed that the first 1000 engines were completed.

The present capacity of the Baldwin Locomotive Works is about 1000 a year. To what shall we attribute this enormous expansion? The enlargement of the buildings and the increased number of employes are important factors, but more men and larger buildings could have been obtained in former years, while the various modern appliances for expediting work were not then invented, and by the aid of these the "impossibilities" of 1840 have become the ordinary realities of to-day. Suppose I should ask any reader of this article who is a mechanic to close his eyes for a moment and form a mental picture of the appearance of the machine shop in which he acquired his technical education and to describe its most prominent features, he would probably say something similar to this: "I see a long, low, dingy building with small windows and little semi-opaque panes of glass admitting feeble illumination; on the floor I see a miscellaneous assortment of machine tools—lathes, planers, boring mills, etc.—crowded together in some places, while elsewhere there are large vacant spaces. I see a number of masts or columns erected at intervals upon the floor, pivoted to foundation plates, and in many instances to the rafters. Attached to these masts are heavy swinging arms, strongly braced, carrying chains and hoisting tackle. A heavy casting is about to be transported from one end of the shop to the other, the chains are attached, the object is raised a few feet from the floor, it is swung round until the arm intersects the circle of the swing of the neighboring apparatus; it is now deposited upon a vacant space on the floor, again raised, again swung round and re-deposited, and so it is moved step by step until it reaches its final resting place. Not only is a great deal of time lost in these operations, but valuable floor space is permanently given up to the hoisting appliances and temporary resting places for the castings are necessarily left vacant." What a change recent years has made. Let us in imagination visit the new erecting shop of the Baldwin Locomotive Works, and see how this business is accomplished to-day. As we enter the shop, which is nearly a block long and half as broad, we are impressed with its unusual height, its light roof composed largely of glass, its immense windows admitting a flood of light and air. Upon the floor we see scores of locomotives in every stage of manufacture. We perceive that the entire floor space is occupied by the work in hand and we look in vain for the huge masts and arms, and, if we have not kept in close touch with recent progress in such matters, we may well wonder how these heavy materials are conveniently and expeditiously handled.

Presently we see an immense hook, not unlike the claw of some gigantic mythological bird, descend from above, grasp a cylinder or a boiler, or possibly a completed locomotive of the largest size, and sail away with it as readily as though it were a toy.

We turn inquiringly to our guide and ask, "What do you call this great mechanical power?" The answer is contained in the title of this article. It is the modern traveling crane.

MODERN GAS AND OIL ENGINES.

By Albert Spies, Mem. Am. Soc. Mech. Eng.

Second Paper.

THE fact has already been briefly noted that not a few of the gas engines now on the market are adapted as well to the use of gasoline as to the use of gas proper, and that only a few slight modifications of design are sometimes necessary, and are provided for to permit changing from one fluid to the other. Such provision is made in the case of the Otto engine, as described in the preceding paper, and also in that of the Caldwell-Charter gas engine, built by the H. W. Caldwell & Son Company, Chicago, Ill., and shown in perspective and in sectional elevation, respectively, in Figs. 13 and 14. In both these views the engine is represented as arranged for the use of gasoline. In Fig. 14 *A* is the working cylinder ; *B*, the piston ; *C*, the inlet valve to the cylinder ; *D*, the mixing chamber ; *E*, a gasoline pump ; *F*, an air-gate worked by the rod *J*, which, in turn, is operated by the governor ; *K*, a gasoline supply regulating valve ; *H*, a gasoline tank ; *N N*, pipe from gasoline pump to a brass pan or reservoir, *P* ; *O*, a supply pipe from gasoline tank to pump ; *Q*, the ignition tube ; and *R*, the chimney surrounding it ; *I* and *L* are air suction pipes taking their air supply from the hollow base of the engine.

The pump *E* works constantly and keeps the gasoline in the small brass pan, *P*, which holds about a quarter pint, at a level fixed by an overflow pipe, which returns the surplus to the supply tank. The air-gate *F* is a brass plate, having two holes so arranged that in normal position a free passage of air is allowed through pipe *I*. When the governor opens the air-gate, the pipe *I* is closed and the air is sucked through pipe *L*. In this pipe is a nozzle leading to the pan *P*, and the passing air draws from nozzle the proper amount of gasoline and forms a combustible mixture of gasoline and air. Each suction takes fresh gasoline from the reservoir, always the same quantity as controlled by supply or throttle-valve *K*, and the charges of gas are therefore of equal strength and value. The ignition tube *Q* is kept at a uniform heat by a simple gasoline burner, furnished with engine. This tube is surrounded by the asbestos-lined chimney *R* which retains the heat. The governor is arranged on the crank-shaft, and through the rod *J* operates the air-gate *F* as already intimated. The exhaust valve, shown at the side of the cylinder, is controlled by a spring and a rod, receiving motion from the larger of two gear wheels. This gear wheel, as will be understood, is twice as large as the smaller driving pinion on the main shaft, and, therefore, makes only half as many revolutions as the latter, thus, of course, opening the exhaust valve only once in every two revolutions of the shaft. The engine, it would seem almost unnecessary to state, works on the Otto cycle. A water jacket, as usual, surrounds the cylinder. The engine, when intended for the use of gas instead of gasoline,

dispenses with the gasoline pump and tank, and one of the suction pipes is connected with a gas supply pipe, in which a gas valve is located. It will be seen, therefore, that at a slight expense the gasoline engine can be changed to a gas engine, or *vice versa*.

A 95 indicated horse-power Caldwell-Charter gasoline engine, developing 65 actual horse-power, is now furnishing power for a large grain elevator at Camden, N. J., and is said to give entire satisfaction. For such large engines the makers supply a self-starter, consisting of a hand pump for forcing a charge into the cylinder, and a detonator for exploding the charge after it has been introduced. This gives the engine its first impulse, after which it continues to operate with its automatic gear.

The Roots engine is built by the Roots Economic Gas Engine Company, London. It works on the Otto cycle, there being one explosion for every two revolutions, but the compression of the gas and air mixture is effected in a novel manner, which constitutes the chief feature of the engine. Figs. 15 and 16 represent a perspective view and sectional elevation respectively. The admission valve, shown on the left of Fig. 16, opens into a special compression chamber. No special gas valve is used, the supply being adjusted by suitably proportioning the gas inlet. To make the manner of working clear, we will assume that one working cycle has just been completed. By studying the sectional view it will then be understood that on the next upward stroke of the piston, or on the suction stroke, the air and gas are drawn in through the admission or suction valve, which opens automatically, and displace whatever products of combustion may be in the compression chamber. The latter is thus filled with

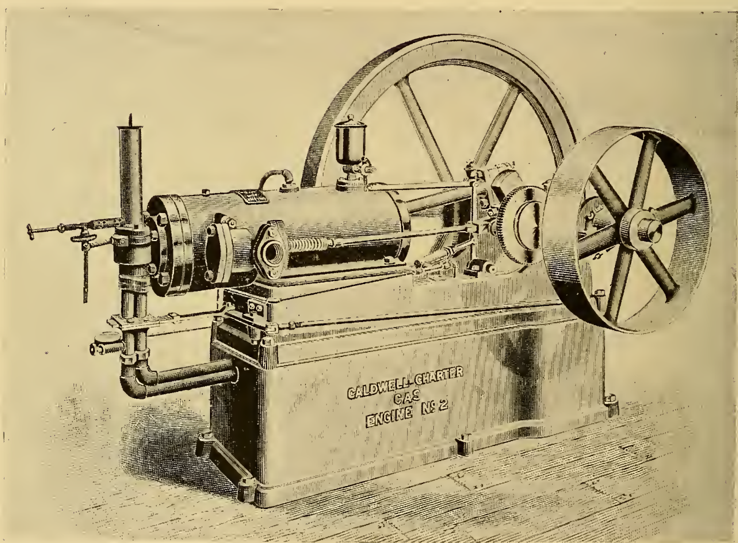


FIG. 13.—THE CALDWELL-CHARTER GAS ENGINE. BUILT BY THE H. W. CALDWELL & SON COMPANY, CHICAGO, ILL.

a rich mixture of gas and air, only a small proportion of which enters the working cylinder through the port *a*. This cylinder, therefore, at the beginning of the first down-stroke, contains a rather dilute mixture of fresh gas, air, and burnt gases, which, as well as the rich charge in the compression chamber, is compressed when the piston descends. Before the piston has gone down very far, however, it passes over the port *a*, cutting off communication with the compression chamber, and during the remainder of the stroke only the dilute mixture in the cylinder is further compressed. At the end of the stroke this mixture is fired by a tube igniter shown at the right. The pressure rapidly rises and the piston commences its working stroke. After having gone a short distançe it uncovers the port *a* leading to the compression chamber, and the rich charge there is further compressed under the influence of the explosion of the weak charge, and is fired. Just how this manner of working affects the diagram is shown in Fig. 17, which is a sample indicator card. After the first explosion, it is seen, the pressure begins to fall, and when the port *a* to the compression chamber containing gas at a low pressure begins to open, this fall is accentuated, but very soon the fresh charge in the chamber is fired, and the pressure line rises again, and is well maintained for a considerable proportion of the stroke. At the end of the working stroke the exhaust valve is opened by the action of an eccentric.

The peculiar system of compression is claimed by the makers to effect a considerable economy of working, the degree of compression in the special chamber amounting to about 120 pounds per square inch. This is considerably more than is ordinarily attained in gas engine compression.

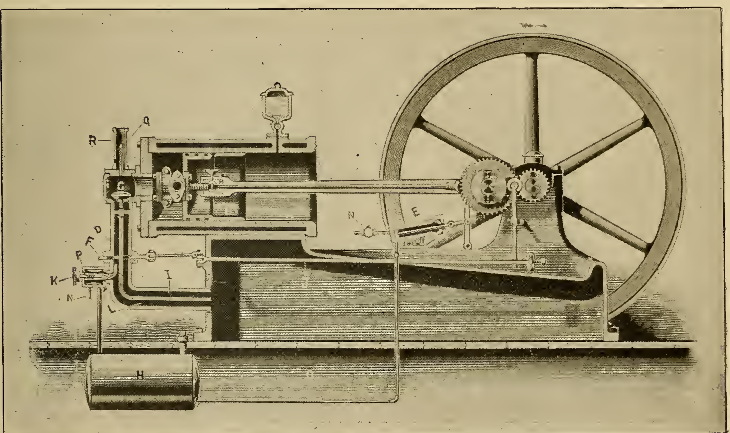


FIG. 14.—SECTIONAL ELEVATION OF THE CALDWELL-CHARTER GAS ENGINE.

A novel form of gas engine built by the Palatine Engineering Company of Liverpool, England, is shown in Figs. 18, 19 and 20, which represent vertical sections and an elevation. The engine is of the vertical type, and the crank and connecting rod are completely cased in. An air inlet valve admits air into the enclosed space when the piston descends. This air is slightly compressed

on the up-stroke, and when the piston reaches the top of the stroke, a quantity of this compressed air rushes into the cylinder through air blow—through ports, the cylindrical part of the piston being then above these ports—see Figs. 18 and 19. At this moment the exhaust valve is opened by the lever *L*, close to the gas admission. The gas is taken into the gas pump, Figs. 19 and 20, and the quantity admitted is determined by the governor and detent, Fig. 19, which control the admission of the gas to the pump by means of the small gas valve.

Ignition of the charge is effected by

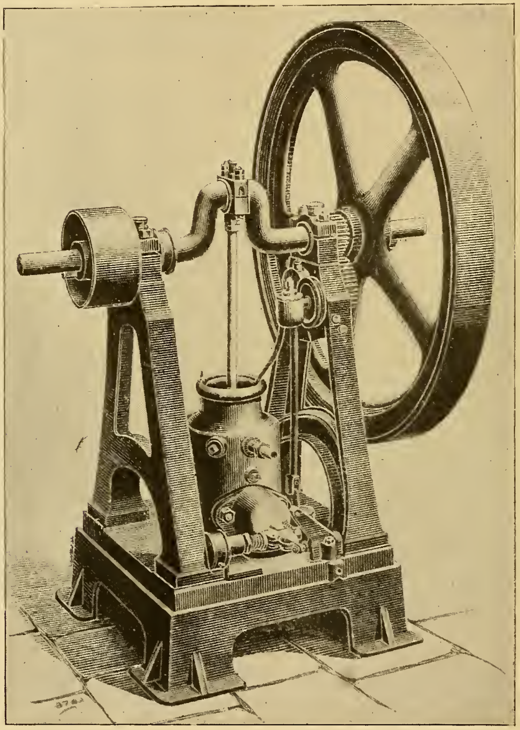


FIG. 15.—THE ROOTS GAS ENGINE. BUILT BY THE ROOTS ECONOMIC GAS ENGINE CO., LONDON, ENG.

Fig. 20, which is operated by one of the cams on the spindle driven by the wheel *W*. The cylinder is thus completely swept out by a charge of fresh air. Referring to Fig. 18 it will be seen that the air suction valve is placed in the space below the cylinder and a tube igniter, *I T*, and the moment at which the charge is permitted to enter the tube is controlled by a valve *I V*, worked by the lever *L*, Fig. 20. The engine, it will be noted, works on the Otto cycle.

The Campbell engine, made by

the Campbell Gas Engine Company, London, shown in Fig. 21, is designed to work according to a cycle in which there is an explosion at each revolution, rupted only by a simple non-return valve. The compressing action of the pump on the back stroke is so timed that the mixture attains a pressure of

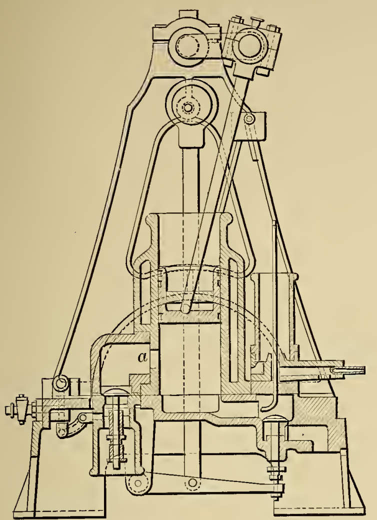


FIG. 16.—SECTIONAL ELEVATION OF THE ROOTS ENGINE.

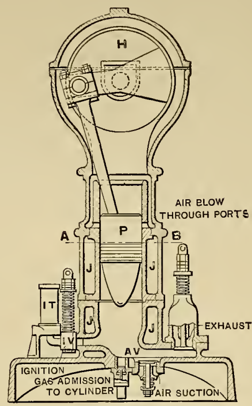


FIG. 18.—VERTICAL SECTION OF THE PALATINE GAS ENGINE. BUILT BY THE PALATINE ENGINEERING CO., LIVERPOOL, ENG.

twice as many, therefore, as in an engine working on the Otto cycle.

This effect is attained by taking in the charge of gas and air by means of a pump, instead of by the action of the main piston. This pump is driven off a crank-pin in the side of the flywheel,

FIG. 17.—INDICATOR CARD FROM ROOTS ENGINE.

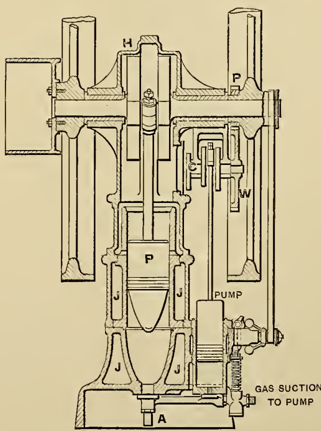


FIG. 19.—FRONT SECTIONAL ELEVATION OF THE PALATINE ENGINE.

and draws in gas and air through ports, controlled by a slide valve. There is a straight connection between the pump and the working cylinder, inter- from six to ten pounds, just as the main piston passes an exhaust port in the side of the cylinder, and allows the expanded, acting charge to escape. The

new charge then lifts the valve and enters the cylinder, driving the remaining products of combustion before it through the exhaust valve. On the return stroke of the main piston the charge is compressed, and at the commencement of the next stroke it is fired by a tube igniter.

The slide valve by which the admission of gas and air to the pump is controlled, is driven in one direction by an eccentric and in the opposite direction by a spring. The connection with the eccentric is not positive, but between the eccentric rod and the valve is interposed a hit-and-miss motion under the control of a governor. When the speed of the engine becomes too high, the governor raises the hit-and-miss device, and the valve is either not opened at all, or is opened only slightly, depending upon the position of the stepped piece, shown in Fig. 22. When the engine is permanently on light work, the amount of the gas and air charge can be reduced by setting the eccentric further around, and the strength of the charge can be graduated by means of a cock on the inlet pipe.

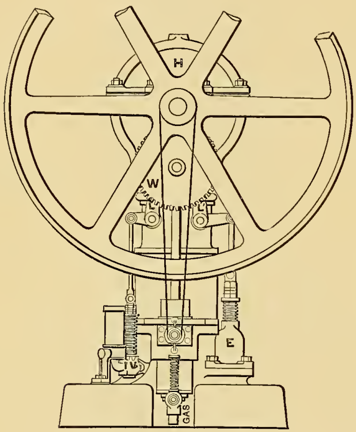


FIG. 20.—SIDE ELEVATION OF THE PALATINE ENGINE.

The several indicator cards, Fig. 23, clearly show the effect of igniting gas mixtures of varying quantity in the engine. So far as structural features are concerned, it will be noticed from the perspective view of the engine that the cylinder does not overhang, as in most gas engines, and the cylinder jacket, engine bed and crank bearings are all cast together in one solid piece.

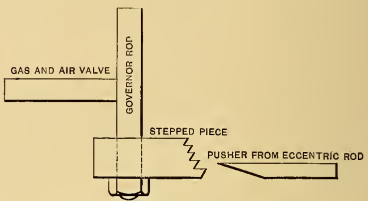


FIG. 22.—GOVERNOR DETAIL OF THE CAMPBELL ENGINE.

In the Foos engine, either gas or gasoline may be used indiscriminately, the design being the same in both cases, the use of gasoline, however, of course necessitating the addition of a gasoline tank or carburetor to the outfit as shown in the general view, Fig 24. The engine is designed to work on the Otto cycle, there being ordinarily one explosion in the cylinder at every second revolution, or fourth stroke.

We will assume, by way of explanation, that the piston is making the first stroke of a cycle, or that, in other words, it is descending and sucking in the explosive charge. The gas then goes to the engine through the valve *O*, and mixes with air coming through the branch pipe and valve *N*. The gas and air mixture passes on through the governor valve *M*, ascends in the


FIG. 23.—CAMPBELL ENGINE INDICATOR CARDS.

vertical pipe shown at the left of the engine, passes through the check valve *P*, and enters the exploding chamber *B* through a lift valve, which ordinarily is kept down on its seat by a spring, *C*, but which opens automatically under the influence of the partial vacuum formed in the engine cylinder during the suction stroke. When gasoline is used instead of gas, air is drawn through the gasoline tank or carburetor, entering at *U*, and in its passage it absorbs sufficient gasoline vapor to make it ignitable. Warm air is used to absorb the gasoline, being led to the tank pipe *U* through the rubber hose shown in dotted lines. This hose is connected to a small drum, *J* on the exhaust pipe *A*. The drum is perforated so as to admit air which, in passing around the exhaust pipe is warmed. The gasoline vapor coming from the carburetor passes through the check valve at *R*, at the outlet end of the tank, and then on to the engine as just described. The engine cylinder and chamber *B* having been filled with the explosive mixture, the piston performs its upward or compressing stroke, during which the charge is compressed. At the beginning of the next down-stroke ignition of the charge is effected in the exploding chamber *B* by an electric spark, caused by the contact and immediately following separation of the inner ends of the two electrodes, *D* and *E*. The arrangement of these will be better understood from Fig. 25. When the two ends *X* and *Y* are brought together, as shown in this illustration, the electric current from the battery provided with the engine is closed, and when they are then quickly separated, a spark is produced, and the gas or vapor charged is exploded.

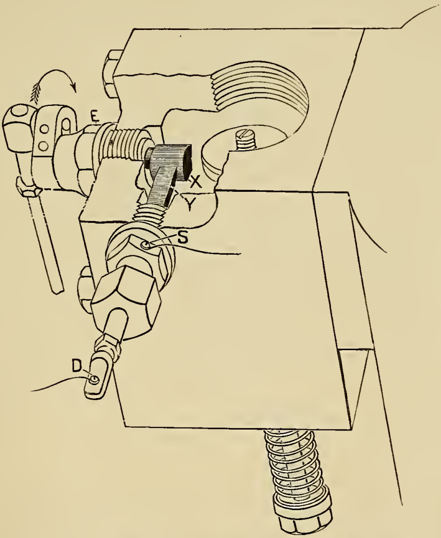


FIG. 25.—IGNITING ELECTRODES OF THE FOOS ENGINE.

The connection and separation of the points of the electrodes is caused by the revolving motion of electrode *E*, Fig. 24, the end of which is made

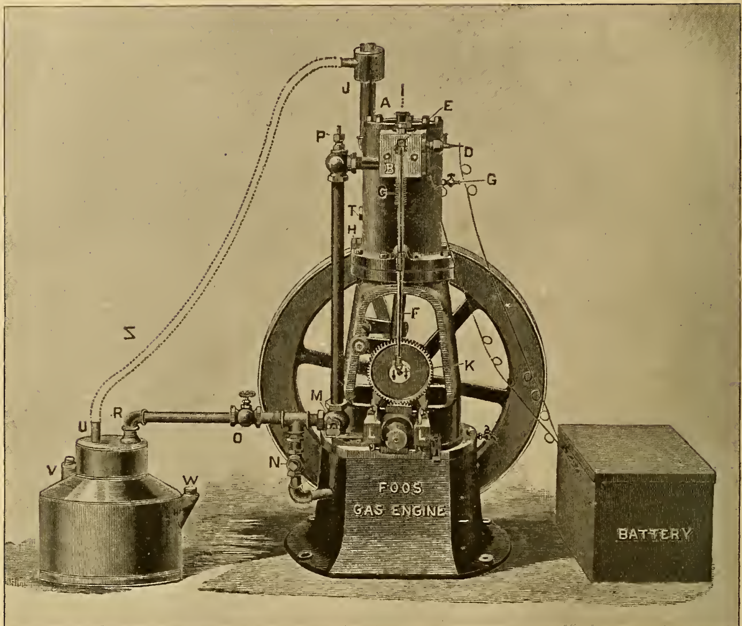


FIG. 24.—THE FOOS ENGINE. BUILT BY THE FOOS GAS ENGINE CO., SPRINGFIELD, OHIO.

in the shape of a half circle as shown at *X* in Fig. 25, bringing the points *X* and *Y* together at every revolution of electrode *E*. Electrode *D* is made to screw further in so that when the inside end *Y* is worn off it can still be kept in contact with electrode *E* at *X*. Care must be taken not to screw it in so far but that there will be a separation of an eighth of an inch between the points of the two electrodes at every revolution of electrode *E*. The latter is worked from the main shaft through the intervention of two gear wheels and the rod *f*, the secondary gear wheel *K* being twice the size of the one mounted on the driving shaft, and, hence, making only half as many revolutions. It follows, therefore, that the electrode end *X* (Fig. 25), will revolve once for every two revolutions of the engine shaft, and, accordingly, will produce an igniting spark once for every two such revolutions.

The explosion having taken place the piston is forced down, making its working stroke, and on the next upstroke the products of combustion are expelled from the cylinder through the exhaust valve and pipe *A* at the back of the cylinder. The exhaust valve, which is of the lift type, is worked by a cam on the spindle of the gear wheel *K*, and by a rock-shaft connection. This valve, which is fitted with a spring to bring it firmly back to its seat after having been opened, and the governor valve *M* are the only valves in the engine which receive positive motion from the engine shaft.

The governor is of the centrifugal type, and is mounted on the crank shaft. Its revolving weights are shown

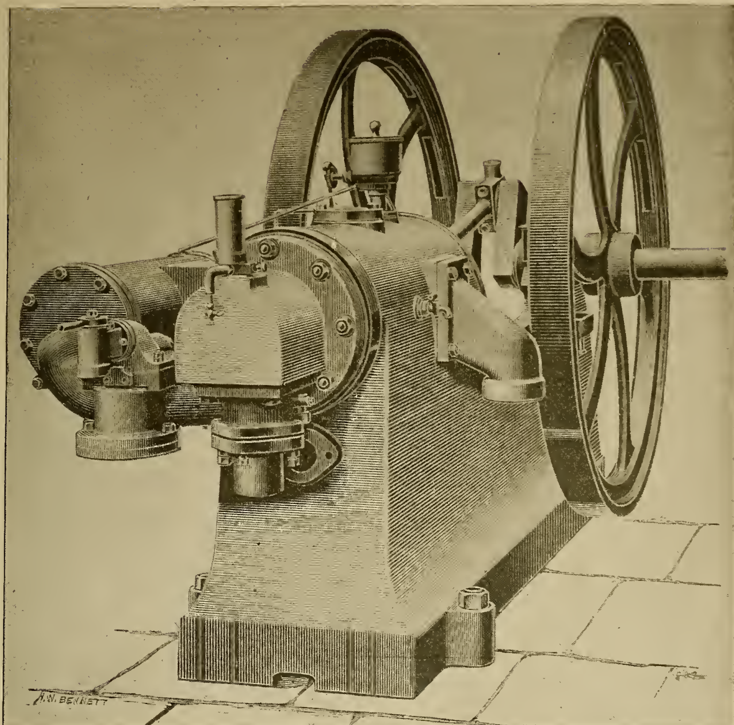


FIG. 21.—THE CAMPBELL GAS ENGINE. BUILT BY THE CAMPBELL GAS ENGINE CO., LONDON, ENG.

at *L L*. These, it will be noted, revolve in the same plane as the fly-wheel, and, when the normal speed is exceeded, fly outward and move a lever controlling the position of the valve *M*, and cutting off or reducing the supply of explosive mixture.

The engine has the usual water jacket to prevent over-heating of the cylinder. In Fig. 24 the inlet and outlet pipes for this jacket are marked *H* and *I*; *G* is a stop-cock for the escape of compressed gas, and is to be opened when starting up ; *T* is an oil cup connection ; *V* is a float in the gasoline tank to indicate the level of the fluid, *W* is the feed opening for tank.

The engine is built by the Foos Gas Engine Company, of Springfield, Ohio, the range of sizes being from two to ten horse-power.

The Priestman oil engine is made both in the United States and England, Messrs. Priestman & Co., of Philadelphia, the American builders, turning out the design shown in Fig. 26, while the English builders, Messrs. Priestman Bros., of London and Hull, have for their latest type of engine the one illustrated in Fig 27. The engine uses for fuel common petroleum such as is burned in lamps, and the quality best suited to this purpose is just what is safest in common use, that is, the highest proof oil. A sprayed jet of this oil is first broken up by compressed

air playing on it in a special nozzle, and then it is further mixed with air, heated and vaporized by the hot products of combustion from the exhaust which are led around a vaporizer or mixing chamber before being allowed to escape. This might be called a regenerator. The oil vapor thus thoroughly mixed with air in proper proportions is drawn through an automatic suction valve into the engine cylinder by the piston in its forward stroke. On the return stroke this change is compressed to about half its bulk, and on the next forward stroke it is ignited electrically producing the working pressure. At the end of this working stroke, as it may be called, an exhaust valve opens and permits escape of the products of combustion during the succeeding return stroke, thus completing one cycle which, it wlll be observed, is the same as in the Otto engine, and to which frequent reference has already been made as the Otto cycle. The oil is burned precisely as it would be burned in the wick of an oil lamp, and all the oil is so burned, except that in contact with the comparatively cool surfaces of the water-jacketed cylinder. Upon these cooler surfaces, the oil not burned is condensed and furnishes the means of lubrication. As in many other engines of this type, there is in the Priestman engine a space at the back end of the cylinder over which the piston does not sweep in its motion. This space, or compression chamber, bears a fixed proportional relation to the whole cubic contents of the cylinder, and acts as the furnace and boiler that is to operate the engine, being, in fact, the seat of power of the machine.

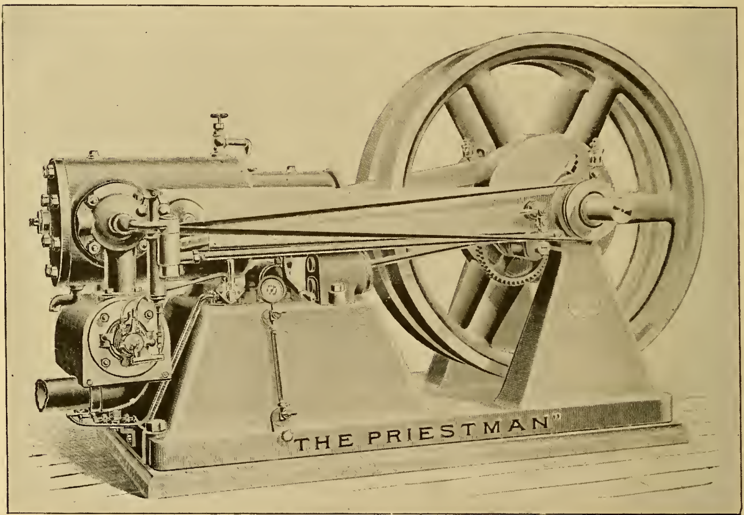


FIG. 26.—THE AMERICAN PRIESTMAN PETROLEUM ENGINE. BUILT BY PRIESTMAN & CO., PHILADELPHIA.

Fig. 27, as already remarked, shows the latest type of the English Priestman engine. This differs from the earlier English design in that the various working parts have been made more accessible, and at the same time have been somewhat simplified. As the illustration shows, the hand pump,

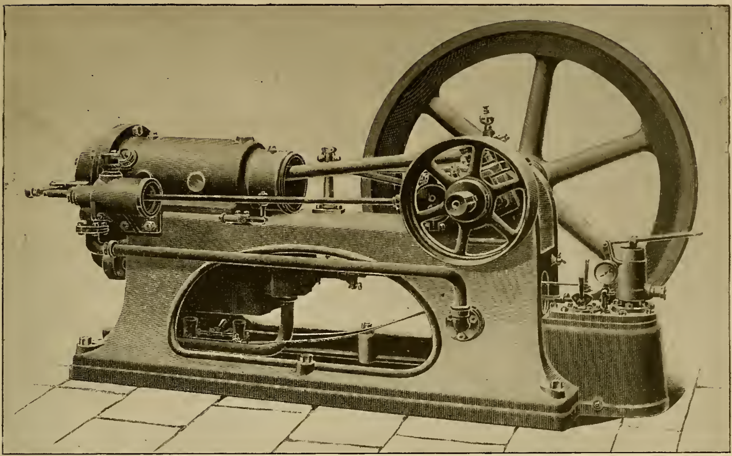


FIG. 27.—THE ENGLISH PRIESTMAN PETROLEUM ENGINE. BUILT BY PRIESTMAN BROS., LONDON, ENG.

by means of which air is compressed into the oil chamber preparatory to starting the engine, is now fitted on an extension of the engine frame in place of being concealed inside this framing, as in the old type. The air pump is also now arranged to be driven by the same eccentric-rod as that which operates the gas valve and firing gear, in place of being driven by a separate rod as formerly. The wide opening in the frame permits of the vaporizer and spray maker being got at in case of need with a minimum of trouble. In all other points the engine is similar to the old type, the action of which has already been outlined.

In the American design, shown in Fig. 26, the idea of making all the parts readily accessible has been still further carried out; hence, the immediately striking difference of appearance. All the main features of the engine are, however, practically the same. In the English engine, it will be noticed, the fly-wheel is placed out-

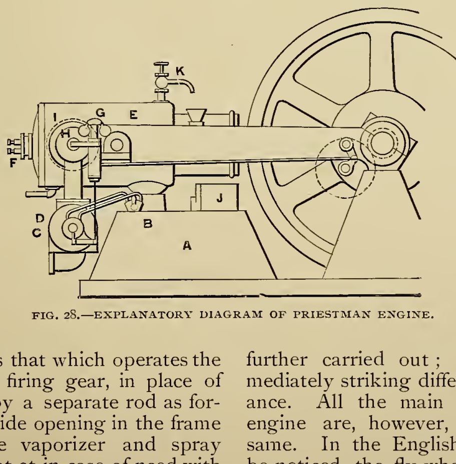


FIG. 28.—EXPLANATORY DIAGRAM OF PRIESTMAN ENGINE.

side of the bearings, and the shock from the sudden ignition of the charge thus comes upon the crank. With the principle adopted in the American design, it is argued that the two flywheels which are used instead of one, and which form part of the crank, offer their great weight to the blow between the bearings and present a mass of sufficient inertia to neutralize the effect of this blow.

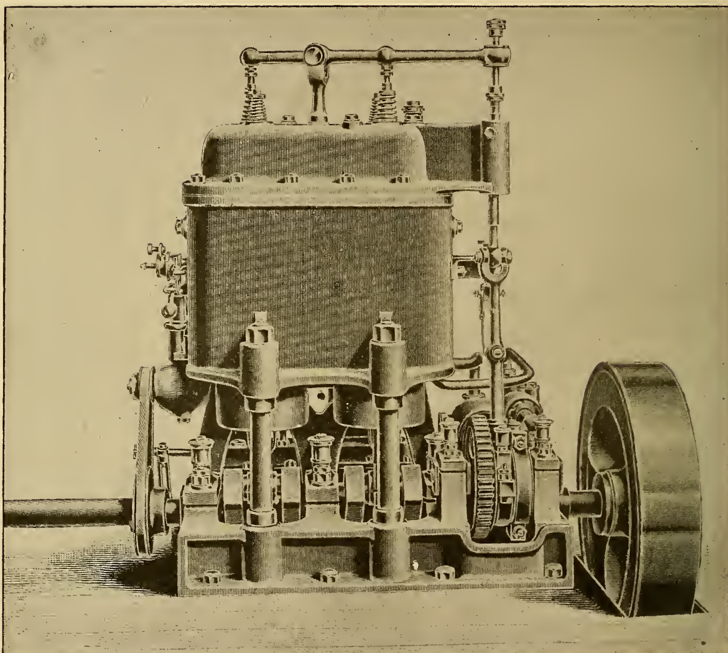


FIG. 29.—THE PRIESTMAN DOUBLE CYLINDER MARINE ENGINE.

The diagram shown in Fig. 28 more clearly explains the operation of the engine. In this illustration, *A* represents an oil tank filled with any ordinary high test (usually 150 degrees test) oil, from which oil under air pressure is forced through a pipe to the three-way cock, *B*, and is thence conveyed to the atomizer *C*, where the oil is met by a current of air and broken up into atoms and sprayed into the mixer *D*. It is there mixed with the proper proportion of supplementary air and sufficiently heated by the exhaust from the cylinder passing around this chamber. The mixture is then drawn by suction through the inlet valve *I* into the cylinder *E* where it is compressed by the piston and ignited by an electric spark passing between the points of the ignition plug *F*, the current for the spark being supplied from an ordinary battery furnished with the engine. The governor *G* controls the supply of oil and air proportionately to the work performed. The burnt products are then discharged

through the exhaust valve *H*, which is actuated by a cam. The inlet valve *I* is directly opposite the exhaust valve. The air pump *j* is used to maintain a small pressure in the oil tank to form the spray. *K* is the water jacket outlet.

The engine at the Philadelphia works is now made in four sizes, ranging from five to twenty indicated horse-power.

One of the various applications ot the Priestman engine has been made by the English builders to the propulsion of a launch which, last year, was running on the river Thames, where she aroused considerable interest. The boat was thirty-six feet long by seven feet three inches beam, by four feet six inches deep. A ten horse-power engine of the marine type, illustrated in Fig. 29, was used, there being two cylinders each nine inches in diameter by nine inches stroke. In principle the engine was the same as the regular Priestman oil engine, the oil being sprayed by a jet of compressed air and afterward heated in a vaporizer kept hot by the exhaust gases. The ignition also was effected electrically, a battery being used to give the spark. The valve gear in the engine, as shown, is very simple. The inlet valves on top of the cylinders act automatically.

The engine was placed amidships and occupied very little space as compared with machinery and boiler space of a steam launch. The speed of revolution was controlled by a governor which cut off a part of the charge according to the amount of work to be done, and the engine was slowed down when required by depressing the governor spindle by hand. The normal speed was 240 revolutions per minute, giving the boat a speed of about nine miles an hour. In this marine type of engine the motion is in one direction only, and reversing is effected by means of a friction clutch which also admits of running the engine detached from the propeller. The boat was easily handled and the machinery required very little attention. About forty gallons of oil, sufficient for several days' running, were carried in the bow, from which the engines drew their supply.

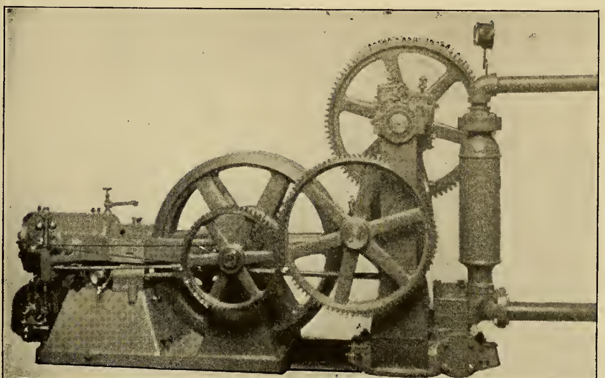


FIG. 30.—PRIESTMAN ENGINE AND PUMP COMBINED.

The Kane Electro-Vapor engine, like the one just described, is also adapted to the use of either gas or gasoline. It is built by Messrs. Thomas Kane & Co., Chicago, Ill., and is shown in Fig. 31 as ar-

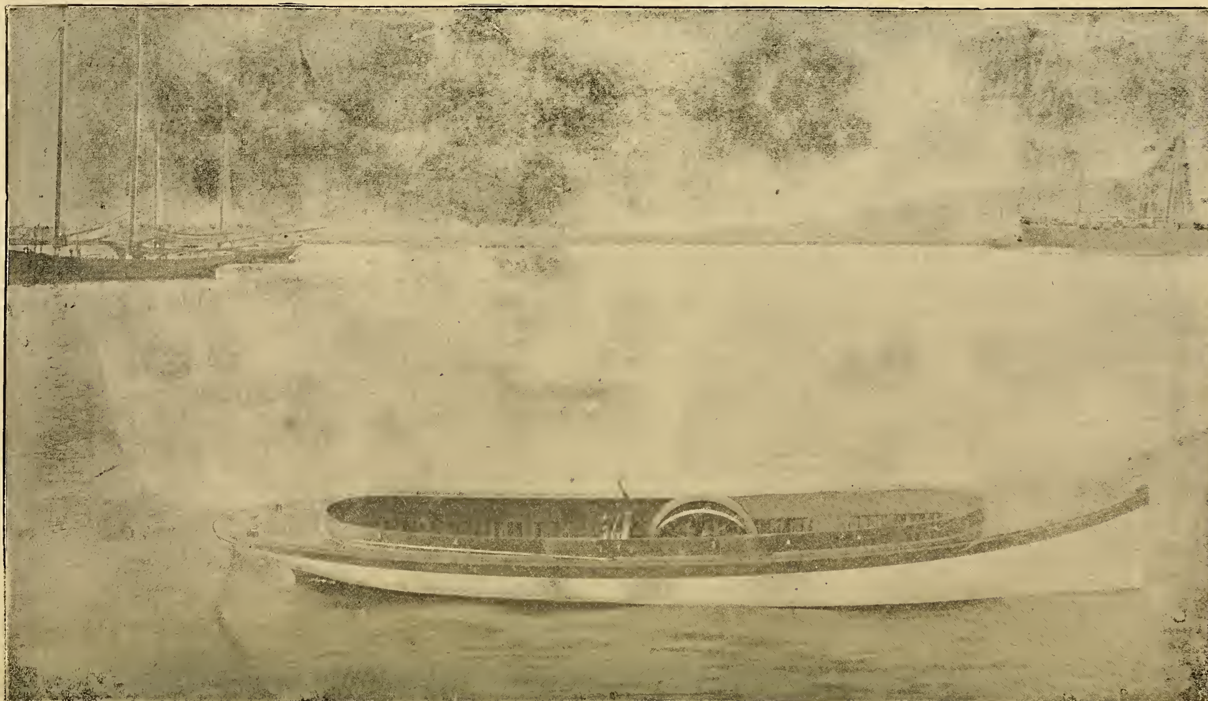


FIG. 33.—KANE ELECTRO-VAPOR LAUNCH.

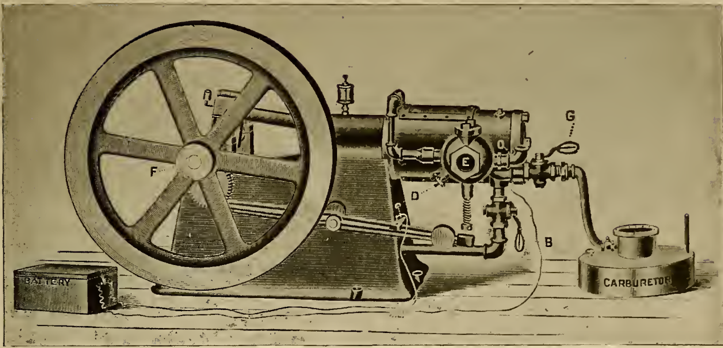


FIG. 31.—THE KANE ELECTRO-VAPOR ENGINE. BUILT BY THOS. KANE & CO., CHICAGO, ILL.

ranged for the use of gasoline. The engine works on the Otto cycle, there being one working stroke in every four. The gas or gasoline vapor goes to the engine through the regulating valve *G*, and mixes with a suitable supply of air, which is drawn in from the hollow bed of the engine through the cock *B*. The admission valve through which the mixture finally enters the exploding chamber is a poppet valve, operated by a lever on the other side of the engine, not visible in the illustration, and controlled by a centrifugal governor through a hit-and-miss device. Having passed through this admission valve during the first stroke of the cycle, the mixture is compressed during the second stroke, and exploded at the beginning of the third stroke, exhaust of the burnt gases, as usual in this class of engines, taking place during the fourth stroke. The exhaust valve chamber is marked *E*, the valve itself also being a poppet valve ordinarily kept closed by the spring shown. It is opened at the proper exhaust moment, however, by being pushed upward by the end of a pivoted lever, which receives motion from the crank shaft *F* through the intervention of a small and a large gear wheel, in much the same manner as that followed in connection with the Caldwell-Charter engine described in the beginning of this paper. The explosive charge is ignited by an electric spark, and one of the electric contact points, connected with one pole of a battery, is carried by the exhaust valve operating lever just mentioned. It is shown at *C* and is pressed against another contact piece on the engine bed at the end of every down stroke of the right hand end of this valve lever. The other pole of the battery is connected by a wire with an insulated electrode in the exploding chamber at the end of the engine cylinder. The second electrode is in the shape of a metallic point carried by the piston. At the proper

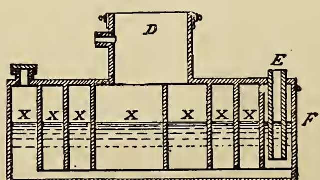


FIG. 32.—SECTION OF CARBURETOR FOR GASOLINE USE.

moment for exploding a charge, the contact pieces at *C* are pressing against each other, and the electrode on the piston, which then is at the right hand end of its stroke, is just breaking contact with the insulated electrode in the

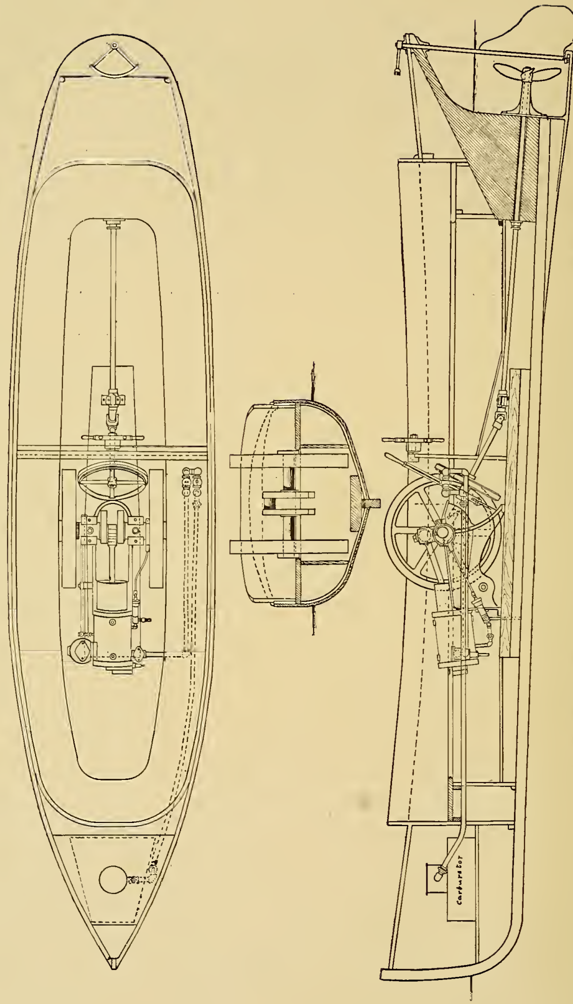


FIG. 34.—PLAN AND SECTIONS OF LAUNCH FITTED WITH KANE ELECTRO-VAPOR ENGINE.

FIG. 35.—KANE ELECTRO-VAPOR LAUNCH.

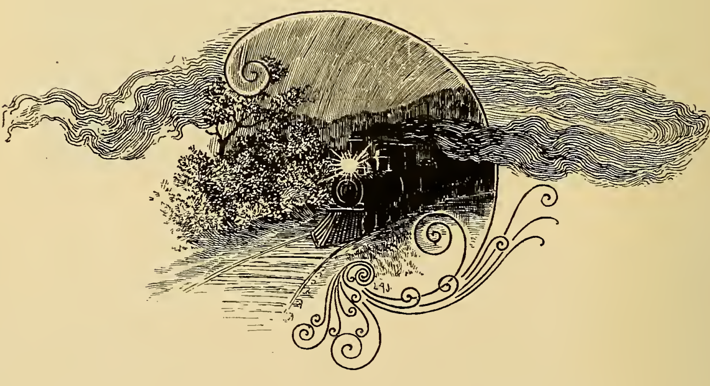
exploding chamber. The result is that a spark is produced, and the charge is exploded. The contact pieces at *C* are for the purpose of completing the electric circuit only at the end of every fourth stroke. At other times they are separated as will be understood from the nature of the connection to the exhaust valve lever. The cylinder is water-jacketted, and the water on its way from the jacket passes around the exhaust valve chamber, cooling it also, and is led off through the pipe *O*.

Fig. 32 represents a sectional view of the carburetor or gasoline tank used when the engine is working with gasoline. It is a small circular tank partly filled with gasoline and connected with the engine by a pipe. It may stand five feet, or, for that matter, fifty feet away from the engine. Upon starting the engine, a current of cool air is drawn

through suction pipe E, and passing around through the circular chamber $X X X$, finally arrives at the gas box D; from there it passes directly into the engine cylinder through the connecting pipe. During its passage through the carburetor, the air absorbs the requisite amount of vapor for the charge. The carburetor works automatically and requires no attention other than that necessary to keep it supplied with gasoline. When the engine works with gas, the carburetor, of course, is not needed, and the end of the gas intake pipe carrying the valve G is then connected directly with a gas supply pipe carrying the customary gas-bag to give uniformity of pressure. The engine is made in seven sizes ranging from one-half actual horse-power up to ten. One of the uses to which this engine when using gasoline is being extensively applied is the propulsion of small boats, and special modifications have, accordingly, been made by the builders to successfully meet the requirements in such cases. Thus Fig. 35 gives a general view of one of the marine engine outfits. The engine, as there used, is fitted up with two fly-wheels and a reversing gear. The latter consists simply of a friction wheel with rubber rim so arranged that when thrown, by means of the lever shown, against the inner side of either one or the other fly-wheel, it will, together with the propeller shaft, revolve either to the right or left as the case may be, moving the boat either ahead or astern while the engine runs always one way, being itself not reversible. With the friction wheel in mid-position, it will be at a standstill. This arrangement provides a noiseless reversing gear and one which will respond at a moment's notice. Fig. 34 represents a plan and sections of a launch fitted up with the engine, while Figs. 33 and 35 are general views.

Messrs. Kane & Co. build also a vertical gas engine, and a special horizontal gas engine and pump combination designed for supplying water for hotels, residences, etc.

(*To be continued.*)



THE LIFE AND INVENTIONS OF EDISON.*

By A. and W. K. L. Dickson.

Sixth Paper.

THE megaphone and aerophone are two of Edison's inventions which have had no commercial application as yet.

The megaphone is a contrivance by which remote sounds may be brought within immediate range of the hearing, without any other medium but the air and a couple of funnels, six feet in height, and mounted on a tripod. These taper from a diameter of two feet six inches at the mouth to a small aperture, attached to which are tubes for the ears.

Persons several miles apart have been known to converse with perfect ease, and what must appear even more incredible, the sound of cattle crunching grass, six miles away, has been distinctly audible to the denizens of Menlo Park. In the construction of the aerophone the same tympanum is used as in the phonograph, but the imitation of the human voice is secured, not by the photographing of the sound waves, but by the opening and shutting of certain delicate valves, placed within a steam whistle or organ pipe, and serving the purpose of controlling the requisite amount of steam or air. The vibrations of the diaphragm, communicated to the valves, cause the latter to close and unclose synchronously with the inflexions of the human voice, the steam or air reproduces these vibrations, and the result is an instrument capable of magnifying two hundred the ordinary tones of speech, and projecting these to an indefinite distance. It is, in fact, a malicious aggravation of the phonograph, which limits itself to reproducing the ordinary inflexions of speech, etc., but which does not presume to tamper with their original volume. The aerophone, on the contrary, not only intercepts casual and indiscreet remarks, but roars them out to the adjoining neighborhood in a manner calculated to endanger the bulwarks of social life. This, at least, was the verdict of the public, when confronted with Edison's new invention, and their attitude was one of comic wrath towards appliances which seemed to threaten their cherished privacy. When we take into consideration the meagreness of our justice, "the rarity of Christian charity, under the sun," the proneness to evil deduction, the thousand hypocrisies engendered by the arbitrary and artificial standards of social life, we may well shrink from the exposure involved in such tell-tale instruments. Yet if these plastic appliances bring with them even that outward cleansing of the cup and platter represented by the purification of external life, their mission will not have been altogether in vain. On the whole, it is safe to conclude that Mr. Edison's position toward society as a benefactor or the reverse will be largely determined by the attitude of that august body toward itself.

Speculations in a somewhat lighter vein are admissible as to whether an indefinite augmentation of scent and sound is to be regarded in the light of an unmixed blessing. Perfumes are certainly in the minority here below, and evil smells in the ascendant; harsh

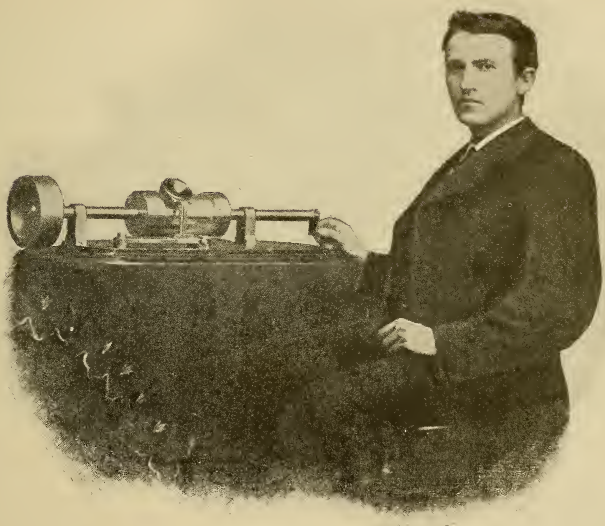
* Began in November issue.

THE MEGAPHONE USED FOR SPEAKING LONG DISTANCES.

sounds and clanging echoes sufficiently invade "the golden spaces of the silence," but if Mr. Edison will promise to waft spicy gales from the planet Venus, or recapture for our gross ears some faint echo of Pythagorean harmonies, we will promise not to impede the progress of his scientific Juggernaut by the interposition of our sublime persons.

Gathering into our remembrance the varied scope of these Edison miracles, we are dimly reminded of certain quaint records and fictional theories which seem to have held in solution the prophetic shadows of our present crystallizations. We are reminded of the enormous funnel constructed by Alexander the Great during his military campaigns for the purpose of heightening and projecting his tones to the most distant portion of his outlying forces; of the mystic sounds evoked from the statue of Memnon, and

of the ingenious acoustic contrivances used in connection with Egyptian and Hellenic worship. Among fictional works of a later date, we recall with peculiar pleasure a marvelous tale, dealing with the creations of a certain sage, in whose person the occult wisdom of the past blended happily with the progressive science of the present and future. Starting with the broad general assertion that "nothing is ever lost" in all the diverse operations of nature, he forms the minor deduction that every sound to which the teeming centuries have given birth (since the opening chorale of the morning stars), is still coursing round and round the globe in ever remoter circles as the years pass on. With a view to recapturing these nomadic strains, he constructed an instrument susceptible of adjustment in such a fashion as to overtake any desired melody in its proper chronological sequence. Every century or section of a century is represented by minute notches, so that it is only necessary to verify dates in order to feast your ears with the music peculiar to that epoch. This theory, as may be supposed, gives scope for many beautiful descriptive passages, foremost amongst which we recall a stirring picture of Miriam's "Song of Triumph," in its setting of resonant cymbals and swirl of Jordanic waves.



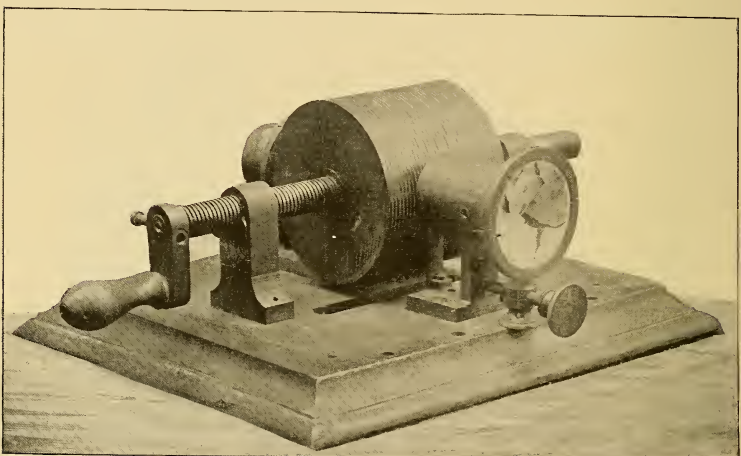
EDISON AND HIS FIRST PHONOGRAPH IN 1878.

May this not have been a daring prefiguration of some of our nineteenth-century marvels? The time is past when we could apply the measuring rod of the past to the boundless possi-

bilities of the future, and there is no reason why fancy should not revel in the brightening landscape which opens to her enchanted vision. What unsuspected arcana in the kingdom of sound are awaiting our restricted hearing, what delicate tintinabulations of fairy hammers, fashioning the shining facets of crystal and gem? What liquid monotones of falling water, shaping the cavernous architecture of stalactite and stalagmite? What soft stirrings in the mystic laboratories of Nature, what riotous coursings of impetuous sap? What symphonies of pent-up fires in the travailing bosom of the earth?

Held close to the heart of the great all-mother, our communion shall be rich beyond the scope of our faint imaginings, and into the narrow areaway of our colorless lives shall steal somewhat of the breadth and beauty of that golden spring-tide when earth and heaven met, to the unsealed vision of the sons of men.

The discovery of the phonograph was based on one of those seeming accidents which enters so largely into the details of experimental science. At the same time, the minutiæ of a certain patent, taken out one year before the discovery of the phonograph, show the trend of his mind, and furnish an intelligent basis for the first rude germs of that marvelous invention. In this patent, Mr. Edison describes "a method of recording ordinary telegraphic signals, by a chisel shaped stylus, indenting a sheet of paper, enveloping a cylinder or plate along the line of a groove cut in the surface of the latter." These indented marks were to be capable of re-transmitting the message automatically over another wire if required.



EDISON'S ORIGINAL TIN FOIL PHONOGRAPH, NOW AT BRITISH PATENT OFFICE MUSEUM.

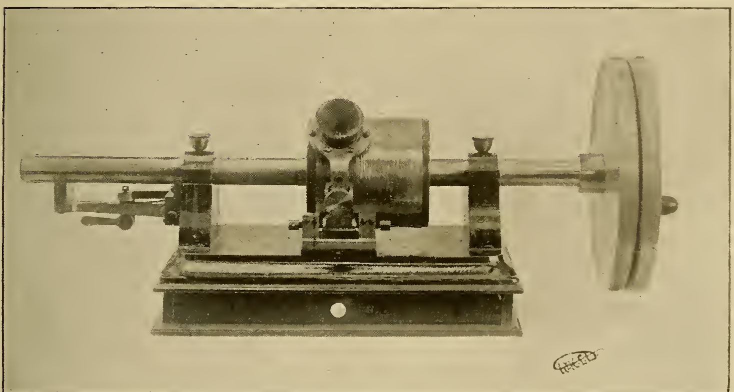
"I discovered the principle by the merest accident," states Mr. Edison. "I was singing to the mouth-piece of a telephone, when the vibrations of the voice sent the fine steel point into my finger. That set me to thinking. If I could record the actions of the point and send the point over the same surface afterward, I saw no reason why the thing would not talk. I tried the experiment first on a strip of telegraph paper, and found that the point made an alphabet. I shouted the words

'Halloo! Halloo!' into the mouthpiece, ran the paper back over the steel point, and heard a faint 'Halloo! Halloo!' in return. I determined to make a machine that would work accurately, and gave my assistants instructions, telling them what I had discovered. They laughed at me. That's the whole story. The phonograph is the result of the pricking of a finger."

A further impetus was given to the idea by the chance suggestion of a noted magnate, the late General Butler, who while examining the construction of one of Edison's telephones, was moved to remark: "Now, Edison, you must make something to record these sounds."

Shortly afterward, the inventor strolled into the Smithsonian Institute and embarked on a close scrutiny of the phonautograph, a machine used for the delineations of the sound waves, in connection with which he delivered himself of the following pregnant observation: "Wise men, these were, not to see that they could put a hard point and a piece of tinfoil in front of it and there is the Phonograph."

Of all the wonders born of Edison's prolific mind, the phonograph appealed most strongly to the imaginative faculties of the public. The daily periodicals competed with each other in poetical rhapsodies, in comic forecasts of its possibilities. Every conceivable vein of pathos, of humor, of speculative fancy, concealed within the vast mines of human thought and feeling, were ardently exploited, and often by no unskillful hands. Antiquarians instituted cunning comparisons between the rude and shadowy theories of the ancients and the symmetrical crystallizations of the nineteenth century. Students were pointed to the giant funnel set up by Alexander the Great, through which the conquerer projected his military directions at a distance of ten miles; to the descriptions given in Goodwin's edition of Plutarch's Morals, viz. in the quaint essay, "How a man may be sensible of his progress in Virtue." "This Antiphanes said merrily, that in a certain city the cold was so intense that words were congealed as soon as spoken, but after some time they thawed and became audible, so that the words spoken in winter were articulated next summer. Even so the many excellent precepts of Plato, which he in-



ONE OF EDISON'S EARLY PHONOGRAPHS.

stilled into the tender ears of his scholars, were scarce perceived and distinguished by many of them till they grew to be men and attained the warm, vigorous summer of their days. The ingenious analogy was first discovered and pointed out by The New York Herald of May 19th, 1878, after which the suspicious resemblance to Baron Munchausen's amazing adventure was drawn for the benefit of students in comparative mythology.

Rudolphe Erich Raspe, a literary aspirant of indomitable if erratic literary ability, writing in the character of his military hero, Baron Von Munchausen, takes occasion to say, in the relation of certain Siberian adventures, "I traveled post, and finding myself in a narrow lane, bid the postilion give a signal with his horn, that other travelers might not meet us in the narrow passage.

"He blew with all his might, but his endeavors were in vain; he could not make the horn sound, which was unaccountable and rather unfortunate . . . . After we arrived at the inn my postilion and I refreshed ourselves; he hung his horn on a peg near the kitchen fire; I sat on the other side. Suddenly we heard a *tereng! tereng! teng! teng!* We looked round and now found the reason why the postilion had not been able to sound his horn; his tunes were frozen up in the horn, and came out now by thawing, plain enough, and much to the credit of the driver; so that the honest fellow entertained us for some time with a variety of tunes, without putting his mouth to the horn—The King of Prussia's March—Over the Hill and over the Dale, and many other favorite tunes; at length the thawing entertainment concluded, as I shall this short account of my Russian travels."

BY PERMISSION OF ILLUSTRATED LONDON NEWS

LISTENING TO MESSAGES FROM EDISON (1888), AT RESIDENCE OF COL. G E. GOURAUD, LITTLE MENLO, UPPER NORWOOD, ENG.

Aristotle's significant reference to Homer's words will be remembered, in which he declares these to be "moving, flying and consequently animated." The following quaint description, from the pen of that "Comic Homer," Francois Rabelais, born in the last

quarter of the fifteenth century, is spiced with a certain antique flavor. Among the few edible portions of that unsavory Olla Podrida, occurs the following ingenious account of a voyage, during which the discoverers "were mightily frightened by various sounds and voices of men, women, children, horses, etc.," floating apparently in the air without any visible corporeal basis.

"Be not afraid, my lord," the skipper makes answer, "We are on the confines of the Frozen Sea, on which about the beginning of last winter, happened a great and bloody fight between the Arismapians and the Nephelibates. Then the words and cries of men and women, the hacking, slashing and hewing of battle axes, the shocking, knocking and jolting of armors and harnesses, froze in the air and now the rigor of the winter being over, by the succeeding serenity and warmth of the weather, they melt and are heard." The author indulges in many other old and merry conceits in the course of his tale. Amongst the unfrozen words, yielding their burden of sweetness or unsavoriness to the balmy air, were some of so hard a nature as to be impervious to softer influences. Such were certain heraldic terms. Vert, azure and black, which being warmed in the hand, melted like snow, giving forth sounds like gibberish. Shade of *Toison d'or*, what a definition of the noble science of heraldry. Other frozen commodities, in which lay concealed the quintessence of murderous thoughts, blasphemy and uncleanliness, being cast into the fire, not only produced sharp and alarming reports, but had an unpleasant trick of recoiling on the heads of those who tampered with them, inflicting many "a slit weesand" and other grim and ghastly wounds. As an offset to these undesirable commodities were some "merry, odd words, the which" remarks the author, with quaint regret, "I would fain have preserved in oil, as ice and snow are kept, and between clean straw." Could the princely giant have floated down the stream of time to the harbors of that enchanted country, the nineteenth century, he would have found his aspirations realized in the Phonograph.

From that strange land of unfathomable antiquity which claims to have been the birthplace of gunpowder, printing, the mariner's compass, cantilever bridges, etc., and the hoary wisdom of whose past contrasts so amusingly with the stultified idiocy of its present, comes the following suggestive tale :

A certain woman of the Flowery Kingdom united to physical loveliness a voice so inexpressibly beautiful, that its echoes stirred the soul strangely, and moved to deeds of love and valor. As years passed on, the beauty of this fair woman became more and more perfect, as all human loveliness must needs, fed on the flame of divine purity and strength. Also the tones of her voice gained in vibrant tenderness, so that her children thought with sorrow of the days in which those accents would be stilled by the icy touch of death. They therefore took counsel with a wise woman who gave them a bamboo cane, endowed with certain magical properties. Into this the beautiful mother spoke, after which the cane was carefully sealed and put away for many years. When several generations had succeeded each other, the ancient legend of this wise and gentle ancestress was revived, and the cane brought from its place. On being opened, the golden accents of the fair woman fell upon the air, freighted with all their pristine sweetness and power. Breathlessly the people listened, and as the last echo died away, they broke into sorrowful lamentations, for alas, the tones of that wonderful voice might never be repeated.

Of later date in the line of predictions is the curious reference in Miss Jean Ingelow's fairy tale "Nineteen Hundred and Seventy-two," first published in 1872.

"He" (the hero) "began to describe what was evidently some great invention in acoustics, which, he said (confusing his century with mine), you are going to find out very shortly.

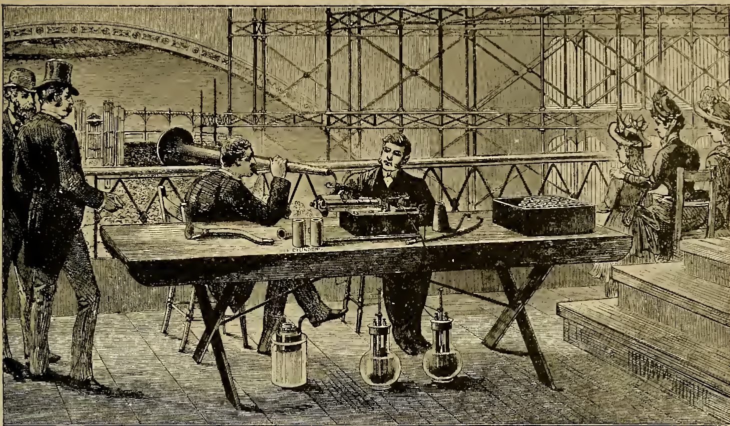
. . . You know something of the beginnings of photography?' I replied that I did. 'Photography,' he remarked, 'presents a visible image; cannot you imagine something analagoús to it which might present an audible image? The difference is really that the whole of a photograph is always present to the eye, but the acoustigraph only in successive portions. The song was sung, and the symphony played at first, and it recorded them, and gave them out in one simultaneous horrible crash; then, when we had once got them fixed, science soon managed, as it were, to sketch the image—and now we can elongate it as much as we please.' 'This is very queer!' I exclaimed. 'Do you mean to tell me these notes and these voices are only the ghosts of sounds?' 'Not in any other sense,' he answered, 'than you might call a photograph the ghost of sight.'"

Miss Amelia B. Edwards is also credited with an ingenious forecast of phonographic principles, and in Hood's comic annual for 1839 is found the following prophetic passage:

"In this century of inventions, when a self-acting, drawing paper has been discovered for copying invisible objects, who knows but that a future Niepee, or Daguerre, or Herschel, or Fox Talbott, may find out some sort of Boswellish writing paper to repeat whatever it hears?"

The inventor himself has joined the ranks of prophets, with results infinitely creditable to his powers of prediction. In those dim days when the phonograph was little more than a spectral possibility, based on the crudest of material foundations, Mr. Edison wrote: "This tongueless, toothless instrument, without larynx or pharynx, dumb, voiceless matter, nevertheless mimics your tones, speaks with your voice, utters your words, and centuries after you have crumbled into

EDISON AND HIS CHIEF ASSISTANTS, 1889.



THE PHONOGRAPH EXHIBITION AT CRYSTAL PALACE, LONDON, IN 1888.—SEE PAGE 459.

dust, will repeat again and again to a generation that could never know you, every idle thought, every fond fancy, every vain word that you choose to whisper against this thin iron diaphragm. I think the world is on the eve of grand and immense discoveries, before whose transcendent glories the record of the past will fade into insignificance."

No prophecy ever received a more minute realization. The phonograph of to-day, in the tenacity of its retentive powers, and in the fidelity of its reproduction leaves absolutely nothing to be desired. Day by day adds to the imperishable records of music and speech. All the burning thoughts of poet and sage, all the liquid beauty, mellowness and vibrant sonority, all the ineffable pain and ecstasy of earth's inspired singers, all the passion and thrill, the subtle coloring of stringed and keyed instruments are being rescued from the gnawing tooth of time and crystallized within tiny cylinders of wax. At last, in the fullest sense of the term, can we be said to be heirs of all the ages. At last, the misty, the erroneous and unsubstantial traditions of the past have given place to the vital and sonorous records of the present. Yet so formed are we, so keen is the edge of pain in all our fancied delights, that we sometimes are led to doubt whether it is altogether well to resign ourselves into the keeping of "deep-eyed Mnemosyne."

"There is a pleasure which is born of pain:
The grave of all things hath its violet,
Else why, through days which never come again,
Roams Hope, with that strange longing, like Regret.
Why put the posy in the cold, dead hand?
Why plant the rose above the lonely grave?
Why bring the corpse across the salt sea wave?
Why deem the dead more near in native land?"

* * * * * *

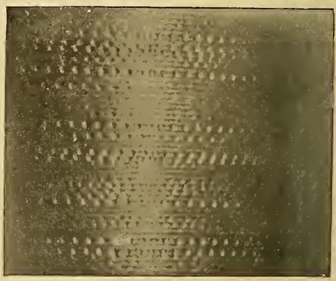
Is it well to call up from that dim place of graves "the touch of a vanished hand, the sound of a voice that is still?" Shall not the dead be free to bury their dead? How else shall Time accomplish his perfect work if that tender messenger, Oblivion, may not lay his velvet touch on straining eyes and bursting heart? Are there no draughts of nepenthe, no streams of forgetfulness under the new regime, and is there sooth in the saying that "Lethe flows not through the Christian's Paradise?" Ah! me, the pity of it, the pain of it!

Yet again—for the mind has many facets, which lend themselves to the reflection of many colored thoughts—may there not be a tenderer, a wiser, a more comforting solution to the sorrowful enigma? Are we to be taught that the new, the sweet, the wholesome sunlight of this enlightened age has power to shine even into these mouldy treasure houses of ours, to arrest the decay and to unmask these poor, shivering spectres who are tricking us in the guise of our redeemed? Are we to learn that death, that livid horror of the infant centuries, is simply an orderly step in life's progression, the stripping of a useless and cumbersome husk, preparatory to the full assumption of that larger freedom, the quickened thought and ripened energy which await us in that fair "Haven where we would be?"

The original tinfoil phonograph or talking machine, now on exhibition at the British Patent Office Museum, London, consisted of a metal drum, grooved throughout its whole width, with a fine spiral thread, over which a sheet of tinfoil was smoothed. The two ends of the foil were pressed together with a slot, cut across the drum, attached to a mica diaphragm, and a needle was made to rest on the tinfoil to receive the indentations, made by speaking against the diaphragm. The drum was centred by a shaft, cut with the same thread and resting on suitable bearings, having two heavy fly-wheels at each end to give it uniformity of speed when turned by hand. The needle and diaphragm were placed at the other side of the drum for repetition, the second needle following the indentation first made.

In the present perfected phonograph, driven either by water or electric motors, the drum and foil are replaced by a composition wax cylinder. The end of the recording needle is shaped like a gauge and scoops out fine particles of wax, while the shaft, traveling laterally over a spiral, composed of 200 threads to the inch, carries the cylinder along the surface. The extremity of the reproducing needle is shaped like a ball, and falls readily into the microscopical grooves, cut into the wax. The diaphragms to which these needles are attached are composed of very thin sheet glass. An all important feature of the present phonograph is the absolutely even pace attained by an automatic speed regulator. Every adjustment is now so greatly simplified that it requires practically very little skill, if any, in the manipulation of the machine.

The impressions made by the phonographic stylus are so marked in form and so logically dependent on the quality and quantity of the tones as to suggest the definition "visible speech."



SECTION OF WAX CYLINDER SHOWING IMPRESSIONS MADE BY HUMAN VOICE (SLIGHTLY ENLARGED).

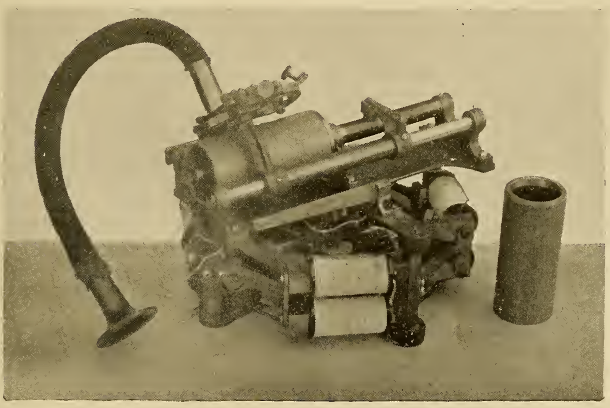
Mr. Edison holds that they are sufficiently legible and consistent to be read by experts, and the truth of his assertion has been partially verified by later investigators, prominent among which were Professors Fleeming, Jenkin and M. Ewing, of the University of Glasgow, Scotland. The impressions secured were irregular, differing widely with the intonation of different people, the force employed and the rapidity of cylindrical rotation. Nevertheless a certain basis of unity was established, which, under the eye of one exhaustively versed in the art, might be susceptible of reduction to practice. The consonantal forms are the deepest, resulting from the superior amount of explosive force requisite to produce them, an attribute which, curiously enough,

the phonograph holds in common with the deeply furred characters of the ancient Runic, in which the consonant played an important part, to the exclusion of the vowels, so largely represented in the softer Latinic speech. As microscopically brought into view, in connection with the earlier sheet of tinfoil, the feminine members of the alphabet were less aggressive in their outlines than their masculine coadjutors, notwithstanding the fact that long *E* vindicated her rights to female enfranchisement by phonetic characters, bearing an alarming resemblance to a brace of Indian clubs.

The indefinite application of the phonograph to literary, musical, legal and commercial purposes opens up a vista of many-sided usefulness, such as few inventions are able to show, and entitle it to a place in future ages such as it is difficult to conceive will ever suffer displacement at the hands of progressive science. It is an indispensable adjunct in the concert room, the courts of justice, in business and newspaper offices, and in every phase of life where a swift and faithful record of sound is desired.

In 1878, Mr. Edison thus summed up the future applications of the new invention:

"Among the many uses to which the phonograph will be applied are the following: 1. Letter-writing and all kinds of dictation without the aid of a stenographer. 2. Phonographic books, which would speak to blind people without effort on their part. 3. The teaching of elocution. 4. Reproduction of music. 5. The 'Family Record'—a registry of sayings, reminiscences, etc., by members of a family, in their own voices, and of the last words of dying persons. 6. Music boxes and toys. 7. Clocks that should announce in articulate speech the time for going home, going to meals, etc. 8. The preservation of languages, by exact reproduction of the manner of pronouncing. 9. Educational purposes; such as preserving the explanations made by a teacher, so that the pupil can refer to them at any moment, and spelling on other lessons placed upon the Phonograph for convenience in committing to memory. 10. Connection with the telephone, so as to make that invention an auxiliary in the transmission of permanent and invaluable records, instead of being the recipient of momentary



MODERN PHONOGRAPH WITH ELECTRIC MOTOR.

and fleeting communications.'' Not only have these claims been more than substantiated, but each year brings with it a series of novel uses such as were undreamt of even by the inventor's far-reaching brain. Medical science has enlisted the phonograph into its service for the purpose of restoring lost hearing. Dr. George H. Leech, of Washington, D. C., one of the most noted specialists of our age, claims that this invention has been most successfully employed in stimulating the dormant or extinct functions of the ear, by means of the vibratory force conveyed from the cylinder of the phonograph to the diseased parts. This result is achieved by the production of a series of continuous successive vibrations at regular intervals, the character, frequency, and intensity of the vibrations being regulated according to the nature or severity of the case.

To the province of speech reproduction, an amusing addition has been recently made. An expedition to South Africa has been actually formed for the purpose of immortalizing the language of apes, with a view to establishing the vexed question of animal intelligence. If the chatter and growl of these gifted brutes can be reduced to order and sequence, our insight into natural history will be immeasurably enlarged. The New York Phonogram, in a brilliant little article on the subject, recalls the human race to a sense of its filial obligations by suggesting that ''If, as scientists have averred, we are descended from the Simian race, and the conductors of this expedition succeed in establishing communication with it, and discovering a new vocabulary, we shall owe to the phonograph the obligation of teaching us our mother tongue.''

A dark outlook for comparative philologists, or rather for that class of learned men whose reputation is based on the deciphering of obsolete inscriptions. Beside the unfathomable antiquity of this tongue, the pretensions of such modern upstarts as Sanscrit, Egyptian, Etruscan or Aramaic, will fade into insignificance ; and the erudition which secured them a fleeting immortality will take its place with the mushroom accomplishments of the day.

In its application to the varied requirements of commercial life, the phonograph is distinguished by extreme simplicity, so that no abnormal demands are made upon the harassed faculties of merchant or clerk. It is only necessary for the business man to talk into the receiver, in a natural tone of voice and at normal speed, after which the sheet or phonogram, as it is called, is received from the phonograph and enclosed in a little box, specially adapted for mail transportation. Sheets of different sizes are prepared by the phonographic agencies, answering to our note, letter and foolscap paper, and embracing any number of words, from 500 and 800 to 4000. The recipient of the phonogram simply places it in his apparatus, and setting the machine in motion, is favored with his correspondent's views, not through the comparatively unsatisfactory medium of pen and ink, but in the familiar tones of articulate speech.

A series of interesting messages were thus transmitted by Colonel G. E. Gouraud, the agent for Mr. Edison's inventions in London, during the exhibition of the phonograph at the Crystal Palace, in 1888. The first phonogram, consisting of a private letter from Mr. Edison to his representative and containing about two hundred words, was received at Colonel Gouraud's house, Little Menlo, Beulah Hill, Upper Norwood, on the occasion of a festive gathering convened ''to meet Mr. Edison,'' and when placed in the corresponding machine, the cylinder gave out such a startling reproduction of Mr. Edison's tones as to be at once recognized by every occupant of the room, not excepting some members of the rising generation, whose tender years absolved them from the charge of personal or scientific prejudice.

The following is an exact transcript of Mr. Edison's message on that occasion :

Ahem! In my Laboratory in
Orange, New Jersey.
June 16, 1888, 3 o'clock A.M.

Friend Gouraud,

Ahem! This is my first mailing phonogram. It will go to you in the regular U. S. mail from New York via Southampton, North German Lloyd steamer Eider. I send you by Mr. Hamilton a new phonograph, the first one of the new model which has just left my hands.

It has been put together very hurriedly, and is not finished, as you will see. I have sent you a quantity of experimental phonogram blanks, so that you can talk back to me. I will send you phonograms of talk and music by every mail leaving here, until we get on the best thing for the purpose of mailing.

Mrs. Edison and the baby are doing well. The baby's articulation is quite loud enough, but a trifle indistinct; it can be improved, but is not bad for a first experiment. With kind regards,

Yours, Edison.

Preliminary to the musical and elocutionary features of the programme were the greetings of the phonograph itself, conveyed in prose and poetry. The first, addressed to the London press, read thus:

"Gentlemen, In the name of Edison, to whose rare genius, incomparable patience, and indefatigable industry I owe my being, I greet you. I thank you for the honor you do me by your presence here to-day. My only regret is that my great master is not here to meet you in the flesh, as he is in the voice. But in his absence I should be failing in my duty, as well as in my pleasure, did I not take this, my first opportunity, to thank you and all the press of the great city of London, both present and absent, for the generous and flattering reception with which my coming to the mother country has been heralded by you to the world."

The second, entitled "The Phonograph's Salutation," by the Rev. Horatio Nelson Powers, D. D., of Piermont on the Hudson, was couched in the following sonorous measures, prefaced by the words: "The contemplation of its wonderful character and performances is overwhelming, and my feelings naturally seek vent in verse. But the phonograph will speak for itself. Now listen to its voice:

I seize the palpitating air, I hoard
Music and speech. All lips that breathe are mine,
I speak, the inviolable word,
Authenticates its origin and sign.

I am a tomb, a paradise, a shrine;
An angel, prophet, slave, immortal friend;
My living records, in their native tone,
Convict the knave, and disputations end.

In me are souls embalmed. I am an ear,
Flawless as truth, and truth's own tongue am I.
I am a resurrection; men may hear
The quick and dead converse, as I reply.

Hail! English shores, and homes, and marts of peace,
New trophies, Gouraud, yet are to be won.
May "sweetness, light," and brotherhood increase;
I am the latest born of Edison.

After some musical selections, chosen for their wide diversity of tone and ranging from the delicate gossamers of a whistled operatic aria to the broad sonority of a cornet and piano duet, the various distinguished guests gathered around the magical instrument, and availed themselves of Mr. Edison's amiable permission to "talk back." The combined result of these conversational efforts reached the inventor early in January, 1889, and were contained in a small oaken box about a foot long. The consignment embraced cylinders from Gladstone, Sir Morell Mackenzie, James Knowlton, editor of The Nineteenth Century; the Earl of Aberdeen, the Earl of Meath, Lord Rowton, a distant relative of Beaconsfield; Sir John Fowler, the builder of the Scottish bridge; Sir William Hunter and Sir Rowland Prothero.

Sir Morell indulges in the hope that he may be privileged to meet the inventor in the near future; other luminaries send messages of cordial appreciation and friendship, and Gladstone conveys his sentiments in the following characteristic fashion: "I am profoundly indebted to you for, not the entertainment only, but the instruction and the marvels of one of the most remarkable evenings which it has been my privilege to enjoy. Your great country is leading the way in the impor-

tant work of invention. Heartily do we wish it well ; and to you as one of its greatest celebrities, allow me to offer my hearty good wishes, and earnest prayers that you may long live to witness its triumphs in all that appertains to the well-being of mankind."

The above phonogram was sent in compliance with Mr. Edison's request, conveyed in a letter to his partner. The inventor's wishes on this subject filtered out, as such things have an occult way of doing, and elicited the following inspired stanzas from The London Globe.

EDISON TO GOURAUD.

"Send Me Mr. Gladstone's Voice."

Send the secret, send it on,
To the land of Washington ;
Ere the profit others make,
Send it me for Humbug's sake.
All the electric box of tricks,
How to split a hair in six ;
How to patch a tattered lie,
Facts forget and deeds deny—
Send me, agent of my choice,
"Send me Mr. Gladstone's voice!"

By those accents which surpass
E'en the best of Yankee brass ;
By those words which seeming plain,
Film with fog the brightest brain ;
By the stone on Blarney's hill,
By the ghost of Mandeville,
By distinctions, false and fine,
By humanely cropt-tailed kine,
Bid my balance-sheet rejoice—
"Send me Mr. Gladstone's voice."

From time to time contributions of equal value were made to phonographic lore on both sides of the Atlantic. Queen Victoria sent a message to the inventor, couched in the most benign terms ; Henry Irving and other histrionic lights added their quota of approval ; golden-toned singers and instrumentalists embalmed their genius for his benefit, but the most superb results were achieved during the Handel Festival of 1888. A gigantic horn, placed in the press gallery of the Crystal Palace concert-room, gathered up the majestic harmonies of the composer, in the several vocal and instrumental settings. Four thousand voices, a thunderous organ and a mammoth orchestra combined in the exposition of Handel's "Israel in Egypt," and this Titanic volume of sound, with its finer contrasts of light and shade was reproduced by the phonograph in a manner little short of the miraculous. These priceless records were duly despatched to Mr. Edison, and exhibited before large audiences in the principal American cities.

Perhaps the daintiest and most suggestive of all the multiform uses to which the phonograph has been put is in connection with the kingdom of toys. The last touch of reality has been imparted to the wondrous wax creations which foster the maternal element in childish hearts by the introduction of vocal tones. Roseate lips lisp out the oft-conned syllables of nursery rhymes, pipe the familiar strains of Mother Goose's ballads, and give forth the cooing and wailing sounds of baby life ; a tiny phonograph, concealed in the recesses of the doll, is the motive power of these magical effects. Under such auspices, into what an enchanted realm will our ordinary toys be transformed ; the inmates of Noah's ark, from stiff, mechanical puppets, will become miniature Barnum menageries, enlivened by the crowing, neighing, mewing and growling peculiar to the animals represented. The mimic theatres will rejoice in a duodecimo edition of the typical showman, giving his attenuated announcements from pigmy lungs, and within the fairy precincts, a band of Liliputian actors will delight their baby audiences by life-like presentments of elfin lore.

The first trio of these gifted Liliputians was presented to the Queen of Holland for the benefit of the royal nursery, whose joyful antics on that occasion gave evidence of the "touch of nature, which makes the whole world kin." In this enumeration may also be mentioned the application of the phonograph to clocks, a field which opens up an illimitable scope of effects, humorous, hortatory, and weird. A recent guest of Mr. Edison's was startled from sleep just at that witching hour "when churchyards yawn and graves give up their dead" by the following awful injunction, "Midnight has

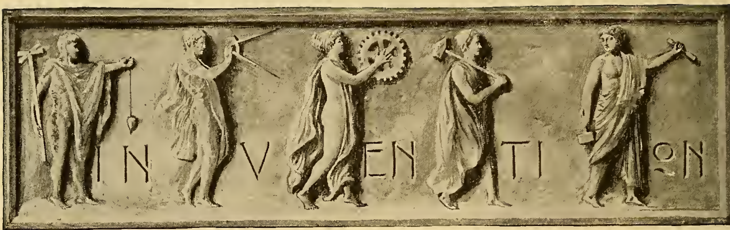
struck! Prepare to meet thy God." The tones were hollow and resonant, and filled the spacious room with weird echoes, but the source of this intimidating remark was nowhere to be seen. Believing himself to be in possession of a valuable contribution to the annals of psychical research, but unwilling, even in the interests of that learned body, to pursue his investigations, the visitor fled incontinently from the chamber franchises. It was estimated at the time that the world's yearly demand for high-priced dolls alone was at least $700,000, and the popular appetite has since been whetted rather than allayed by familiarity with phonographic embellishments. Shortly after the foundation of this company, orders to the amount of $200,000 were received in this country alone, $80,000 emanating from the Pacific Coast trade, $200,000

PHONOGRAPH APPARATUS FOR DOLLS.

into the passage, where, fortunately for the preservation of his remaining wits, he was met by Edison himself, and reassured in the following words: "Don't be scared, old man, it's nothing but a clock."

The increasing demand for these perfected playthings gave birth to the Edison Phonograph Toy Company, incorporated toward the close of 1887, and capitalized for $600,000, of which $400,000 was issued for patents and were put on sale at the Paris Exposition, and cash offers ranging from $165,000 to $350,000 for the exclusive right of European sales, poured in upon the inventor. Factories were established in Europe for the construction of the dolls' bodies, and these being forwarded to the phonographic works at Orange, N. J., were equipped with the necessary vocal apparatus, $3000 per day being the average achieved in 1889.

(*To be continued.*)



NOTES ON NEW AND PATENTED INVENTIONS.—VII.

By John Richards, M. E., Editor of "Industry."

ON the following page is shown an illustration of an invention for moving cars. The plan proposed is to suspend railway carriages from the top, at one side, so they will bear laterally at the bottom against drums or friction wheels set along the permanent way at intervals less than the length of the cars. There are to be two sets of cars, one on each side of the supporting structure, the distance between them spanned by the friction drums, so the traffic is driven each way by the same drums.

In the diagram, *A* is one of a series of posts or pillars for the permanent way, *B* supporting rollers on which the cars *C C* are suspended at the sides, and *D* one of the friction drums between. Other details do not require explanation here, as the purpose is not to consider this particular invention so much as making it a text for some remarks upon the frictional element involved, and some other methods for propelling railway traffic.

Frictional apparatus of all kinds is the *bete noir* of mechanics. Its success in the case of driving bands has led to all kinds of expedients for introducing it into machines, successful and indispensable in many cases, unnecessary and a failure in still more cases. The method involves so many vague factors and conditions that it is not always easy to determine beforehand whether friction or traction is suitable or not.

The limitations as to endurance are the extent and velocity of movement that takes place between the surfaces in contact and the pressure or pressures divided by area. The ascertained data need not be discussed here, it is available elsewhere and is much easier to follow out and understand than the phenomena that arise in various examples of application.

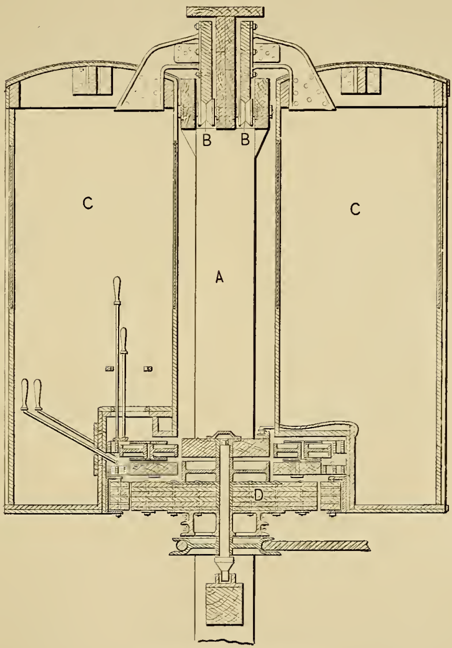
Such apparatus can be divided into two classes. One wherein contact is theoretically but a line, as when both surfaces are convexed or curved, or one is curved and the other a plane. The other class where the faces in contact are parallel, or, as we may say, fit together. In the first class, most extensive of all, is railway traction by locomotives, by frictional adhesion of their wheels, that equaling from twenty to thirty per cent. of the weight or the pressure.

This is a peculiar case, without parallel in machine work, or machine uses of frictional methods. The contract is that of a circle meeting a plane in two directions, the curved wheel and

flat rail in one plane, and the curve on top of the rail meeting a plane across the face of the wheel the other way, an arrangement no one would think of adopting in designing frictional gearing. Another peculiarity and cause of high tractive force, is in the pressure being produced by gravity, hence certain, uniform and measurable, never relaxing, and free from all the operative contingencies that attend upon springs or other devices to press the surfaces together.

Cable traction for railways is another peculiar application of the friction method, varying in several respects from common friction gearing. In no other case is there so much sliding of the bearing surfaces, a result caused by the weight and inertia of the mass to be put in motion, and the frequent stops and starts, also the sliding that takes place when the cars are moved at a slower rate than the cable.

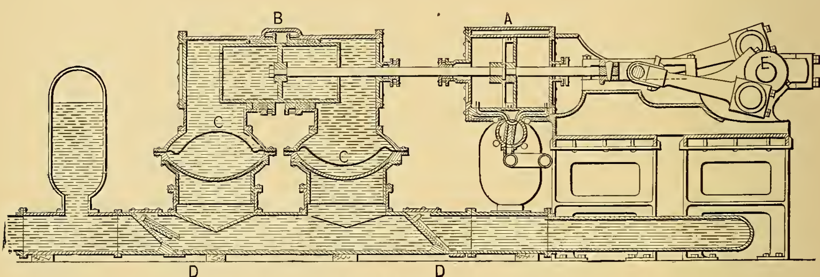
To offset this sliding and consequent wear of the surfaces there is fortunately an enormous amount of surface to withstand wear. A cable two miles in length has from 3000 to 4000 square feet of surface, and notwithstanding the very adverse circumstances of use, such as rough surfaces covered with grit and dust, the endurance bears a fair proportion to the area of contact. The shoes or clamps that bear upon the cable are destroyed at a rapid rate, but these are quickly replaced. The life of a cable under ordinary use can be set at a year and a half, and the wear of clamps at one pound of iron ground away for every ten miles of service. The bearing area is from fifteen to



TRANSPORTATION SYSTEM.

thirty inches of parallel surface, but not acting in the manner of planes, because the impingement is in one direction only, and the effective surface not more than one half the area in contact.

It will not be necessary to consider other cases of frictional traction to arrive at some conclusion respecting the probable result of driving a car by means of a third or fourth of its weight bearing against friction wheels, to say nothing of the maintenance of driving drums throughout a line at intervals of less than the length of a car. Without computation we imagine the axle and rolling friction could not be provided for in this manner, even on a level grade.



BOOTH'S STEAM PUMP.

U. S. Patent No. 482,840, Sept. 20, 1882.
C. H. BOOTH—STEAM PUMP.

This patent relates to dredging or sludge pumps for raising and conveying material, such as will wear or foul the pistons and valves, and consists in interposing between the pistons and the liquid or material to be pumped, flexible diaphragms, the pulsations of which coincide with the movement and displacement of the pump pistons. In other words, the water in the pumps is retained there, and the pulsating diaphragm below the pump becomes in effect a second piston, acting on and impelling the material to be pumped.

The drawing above will very clearly indicate the method of operating and the construction of one pump and engine, there being three set side by side, so their united action will produce a continuous flow in the discharge and suction pipes, both of which are common to all of the pumps.

A is the steam engine, *B* the pump, and *C C* the flexible diaphragm, one being shown on the inward and the other on the outward stroke. *D D* are valves, and *E*, a three-throw crank shaft to regulate the stroke and maintain the proper relation and movement of the three engines and pumps.

The scheme is novel, and in pumping sand the machinery would be protected from wear, or as we may say destruction, because no piston pump can last but a short time with sand passing through it, but there is a question of the expediency in employing such pumps for this kind of duty, and not only in respect to their endurance but also first cost and efficiency. The principal thing of all is, however, whether the flexible diaphragms can be maintained at a reasonable expense, especially in dredging where there is stone, or as in harbors everywhere, a miscellaneous assortment of scrap iron to be passed through pumps. In a recent case a fifty-pound Dahlgren shell came through a dredging pump at Honolulu.

Dredging pumps are what may be called an undeveloped branch of machinery at this time, and experience goes to show that in pumping sludge or sand, especially the latter, an intermittent flow, such as is unavoidable with crank motion, is not suitable, because of the period of rest permitting

precipitation. Precipitation means clogging in the case of drift sand or fine sand. A deposit of this in the pipes or water chambers is hard to remove by a current.

The finer the sand the harder the deposit. In the case of very find sand that has been deposited by wind, such as is common along the Pacific Coast, where the prevailing winds are "on shore," it will sometimes "build in" a vertical pipe forming an annular stratum, closing the bore until the flow is stopped. This is an extraordinary result, one that can be prevented, however, by a rotation of the water in the pipes, produced by some kind of spiral deflecting apparatus.

We speak of sand especially, because it is the most difficult to handle. Silt, clay, or indeed any material soluble, or light enough to be easily maintained in suspension, offers no difficulty in pumping by centrifugal machinery in which no valves are employed and the flow is regular. As to valves, such as are necessary in piston pumps, and especially pumps driven by cranks, which require that the valves close at each stroke, we must express doubt as to their successful working in such material, no matter what the form of the valves may be.

Weight for weight, and cost for cost, there is no doubt that the cost of centrifugal pumping apparatus for dredging has double the capacity possible by any other system to deposit the "spoil" on the shore, or at a distance. In fact, the pumping part is one of minor importance compared to either getting the material into the pump, or from the pump to the place of deposit. Securing the spoil is the most difficult part. An experienced man, who has been engaged for a number of years in operating dredging pumps, recently remarked : "After I get the material into the suction pipe there is no further difficulty, the real problem lies beyond that point." Included in "securing" the spoil, is the movement or adjustment of the apparatus employed. This is commonly supported on a swinging boom or frame, that with the pontoon or barge on which all is mounted, turns on a pivotal point, advancing at each stroke or cut, by means of extensive and complicated tackle, so that dredging by pumping, is hardly a problem of pumps, or at least the pumps are not the most difficult portion to maintain.

British Patent No. 10,822, June 25, 1891.
C. N. JACKSON—SUBSTITUTE FOR GUTTA PERCHA.

This patent is for a composition of paraffine wax, India rubber and bitumen, combined at a suitable temperature. The paraffine 10 parts, bitumen 1 part, are combined by digesting them in a "vulcanizer" at 300 to 400 degrees of temperature. The temperature is then lowered to 200 or 212 degrees, and two parts of India rubber added. This compound, it is claimed, is water-proof, very tenacious, a perfect insulator, and not susceptible to oxidation as India rubber is.

Supposing the qualities are as claimed, and four-fifths of the mass to consist of commodities costing less than one-half as much as India rubber, the invention is one of no little commercial importance.

The search for compounds constitutes in some respects a distinct branch of invention, or discovery rather because the term inventionn, in its true sense, does not apply to such cases. Chemical results are tentatively arrived at, and primarily the result of experiment. The processes of research do not admit of inductive treatment. The reactions and combinations of natural elements, although set out in precise formulæ so far as known, have been empirically derived, and for that reason there is always promise of new results. The scarcity or high price of India rubber, and its multifarious uses in the arts make its substitutes a fertile field of experiment, but it has thus far been almost a barren one.

The consumption is enormous. From Para, in Brazil, shipments to the United States are over 8,000,000 kilograms a year, worth about one dollar per kilo. According to Consular reports from Guatemala, the exports to the United

States from there are about 130,000,000 pounds a year, worth fifty cents a pound, making from these two countries alone over $73,000,000 worth of India rubber annually imported into this country.

U. S. Patent No. 479,651, July 26, 1892.

R. M. LOWNE—ENGINE.

The engine shown and described in this patent would be a proper subject for Professors Hirn or Thurston. It involves a thermal problem as an abstract proposition. The inventor proposes to introduce into a cylinder heated gases on the outward stroke, and by the cooling of these gases form a partial vacuum on the inward stroke of the piston, the power being thus derived from the atmosphere. The inventor is of East Finchley, London, England, and from the drawings and specification we infer has not been engaged in making such engines.

The hot gases are, in the present case, generated by gas burners, which, for anything described in the specification, waste their heat on "desert air," between the intervals of being drawn into the cylinder, which must be considerable more than one-half the time.

U. S. Patent No. 482,876, Sept. 20, 1892.

BERNHARD H. MUNSCH—GAS COMPRESSOR.

This invention comes from Hastedt, Germany. Its purpose is to save and return any gas that may escape around the piston rods of compressing pumps for air, ammonia, or other volatile fluids dealth with.

The invention consists of an auxiliary pump barrel *A* around the piston rod *B*, having a close fitting piston head *C*. Any gas escaping through the main gland *D*, passes into the pump barrel *A*, and is expelled at *E* by the outward stroke of the piston *C*, and any gas leaking a second time past this piston, is expelled at *F* and conducted from there to the inner end of the barrel *A*, to be forced out through the discharge *E* leading to the suction or inlet of the main pump or compressor. It is, in substance, a second air pump to take up and return any gas leaking around the piston rod of the main compressor.

This invention we do not notice with respect to its mechanical features, so much as one presenting a good subject on which to form an "economic equation" in which the amount or value of the gas that escapes around a piston rod with common packing, should equal the extra cost, room occupied, and maintenance of the added devices involved in the invention. Every new invention can with more or less certainty be reduced to a commercial problem by setting on one side the value of the functions gained, and on the other side the cost of providing and maintaining new apparatus directed to these functions. In some cases, but not many, the functions are increased or improved and at the same time the agent or means is simplified and cheapened. Such inventions are the most valuable and exceed the rule once before laid down in these notes, that in order to succeed commercially, a new invention must produce better results at the same cost, or the same results at less cost.

In the present case, it is assumed that there is a certain quantity of gas escapes around the piston rods of the compressing engines or pumps, that this gas has a certain value in excess of the first cost, room required, and maintenance of the invention; also, that the present means is the best yet devised to prevent such loss. These are the obvious assumptions on which the patent is based, and by their truth or fallacy must be determined its value. Practically, the piston road *B* must be made enough longer to receive the auxiliary pump, which having the same stroke as the main one, doubles the working length of the piston rod, adding nearly a stroke and a half to the length of the main frame, foundations, and the longitudinal space required, also entails the maintenance of a second piston head, two valves, a packing gland, pipe connections, and unless the escaping gas is offensive or dangerous, its value can hardly pay for these additions and their care.

Then again, if the pump is horizontal,

the piston rod *B* could be supplied with two packing boxes having a water chamber between, that would seal the outer one against the escape of gas, which would collect on top of the water and could be conducted back to the induction pipe of the main pump, even under pressure. We are not finding fault with the invention, but suggesting methods of analysis in such cases, and pointing out that ingenuity, which is strongly marked here, may have but little commercial value.

A NEW GRADUATING STEAM RADIATOR.*

By John T. Hawkins, M. E.

SOME of the most serious objections to steam heating by direct radiation, as now effected—particularly in residence buildings and similar situations—are too well known to require more than passing notice.

The impossibility of adjusting the heating effect of the ordinary steam radiator to changes in the temperature of the outer air is probably the greatest objection to that system ; the facility with which this adjustment is effected in the hot-water systems constituting the principal advantage which the latter possesses over the former ; while the simplicity and perfection with which the combustion in the furnace is automatically regulated in the steam system gives it an equally decided advantage over the hot-water system ; to say nothing of the greater first cost of the latter.

In direct radiators, located in residences, offices, and similar places, there is much annoyance and often no little damage, or both, from both systems, resulting from leakage through the stuffing-boxes of inlet or outlet valves, or both, or through that more prolific source of annoyance, the air-valve ; whether the so-called automatic or the simple pet-cock, located in the ordinary steam radiator, as they almost invariably are, some distance below a level which the water of condensation is liable to reach in case of defective closing of inlet or outlet valves, or the leaking of these valves themselves when closed as tightly as may be ; or, as the writer has more than once experienced in his own residence, by the furnace attendant neglecting to shut off the boiler feed, entering the boiler under the city pressure, until all the radiators in the house to the top story had become filled to the top.

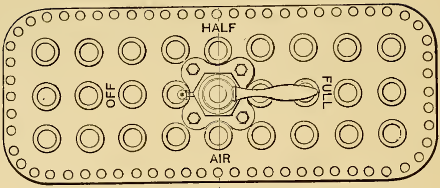
In the hot-water systems, one of the dangers is that of an isolated radiator becoming subjected to freezing temperatures, and, as a consequence, a rupture and leak which results in more or less damage to the premises.

In designing the apparatus shown in the illustrations it has been the object of the writer to avoid each of the objections named, by producing a steam radiator which may be regulated to any degree of heating effect at will ; one that will have absolutely no openings to the air of any kind below the highest possible level of water in it ; one that will render the use of an automatic air-valve unnecessary, by automatically expelling or excluding the air from itself when shut off, and preclude the possibility of freezing so long as fire is kept under the boiler, whether the given radiator be isolated in heating effect from the others or not.

As shown in the illustration, also, it has been attempted to produce a general arrangement or construction of radiator which will be, for a given radiating surface, as cheaply made as the

* Paper read before American Society of Mechanical Engineers.

Fig. 156.



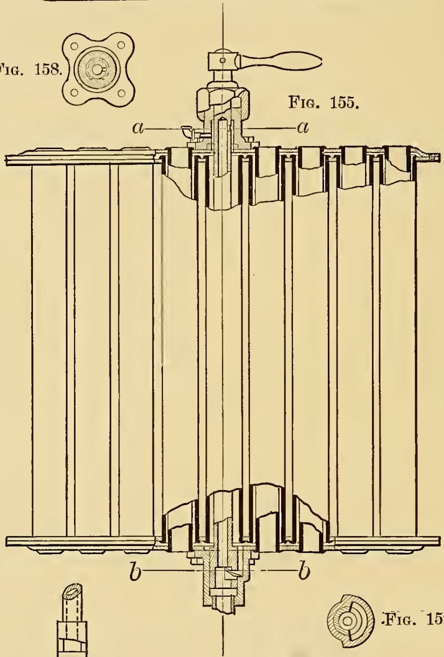


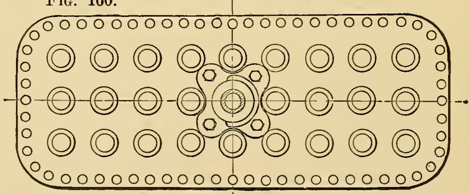
Fig. 158.

Fig. 155.

Fig. 159.

Fig. 160.

Fig. 157.



cheapest form of steam radiator for equivalent use now on the market, if not cheaper than any.

The construction illustrated is such, also, as to contribute a minimum volume of water or steam space, in order that desired changes in graduation of the heating effect may be accomplished with reasonable quickness by the filling up from condensation, as hereafter explained. This is a necessary feature in this plan ; it may, however, be observed in cast-iron or other constructions quite as easily.

The heating effect is graduated by varying the opening for the water discharge—which is by no means original with the writer, except as to the manner of effecting it—and providing for automatically preserving such level of water of condensation as may be decided on. When set for any particular amount of heating effect, the water level cannot vary except within small limits, as it may be affected by local and immediate changes in the temperature of the air of the room. This feature the writer believes to be entirely original with him.

Of course, it is understood that in such an apparatus, if it be kept partially filled with water, this water will cool down because it will not conduct the heat of the steam downward—the steam being in contact with it at the top only—and will thereafter radiate but little heat.

To shut off the heating effect altogether the water discharge is entirely closed and the radiator allowed to fill entirely with the water of condensation—which, owing to the small volume of water space, will quickly occur—in which case, of course, there is no chance for the accumulation of air within it as it cools off ; so that, when turned on again, no discharge of air becomes necessary, and nothing more than the ordinary pet-cock is required for use—and this only when starting up the system—placed above the highest possible level the water can attain ; and this cock being always kept closed, whether the radiator is in or out of use, no leakage can take place through it.

In the illustrations, Fig. 155 is a side elevation, partly in section through the centre row of tubes ; Fig. 156 is a top view, and Fig. 157 a bottom view. Fig. 158 is a horizontal section through the upper bonnet at the line *a*, *a*, Fig. 155 ; and Fig. 159 is a similar section through the lower bonnet at line *b*, *b*. Fig. 160 is a side elevation of the valve end of the central tube. In the construction shown the apparatus is made up of a pair of boiler-iron heads at the top and bottom, into which the pairs of tubes—inner and outer—are expanded after the manner of boiler tubes, the steam and water occupying the narrow spaces between the pairs of heads and between the inner and outer tubes. This gives a very large amount of air-heating surface and a small volume of steam or water space. The vertical inside tubes, acting as flues, constitute the most effective kind of air heating surface.

Secured to the upper head is a bonnet, provided with the customary stuffing-box. Through this stuffing-box passes the closed end of a small central tube, made of brass or other highly expansible alloy or metal. This tube has secured to its upper end a handle, by means of which it may be rotated. This brass tube also has a small opening in the side near the top of the tubular part, opening into and near the top of the chamber within the bonnet. At the base of the bonnet the brass tube is provided with a collar, fitting in a recess between the base of the bonnet and the top of the upper head, for the purpose of fixing the position vertically of the tube, or, rather, of its upper end. This collar is perforated with a number of small holes, as seen in Figs. 155 and 158, through which communication is maintained between the chamber of the bonnet and the steam space of the radiator. A small pipe enters the bonnet at the left, to which the ordinary pet-cock may be attached at a level above the top of the bonnet chamber, for the discharge of air as above explained. The central brass tube passes down inside the central radiating tube of the apparatus, in this

case taking the place of one of the inner flue tubes. Its lower end is enlarged into a cylindrical valve fitting the inside of another bonnet secured to the bottom head, except for a part of its depth, where the bonnet is chambered out to a larger diameter for nearly half its circumference, to permit the entrance of water to and through the valve. The opening in the valve is helical in form at the top, and the lower limit of the bonnet chamber has a corresponding helical form, so that as the tube is rotated, and with it the valve at its end, the opening from the bonnet chamber to the interior of the valve or tube may be wholly or partially closed. A variation in the area of this opening will also occur for any rotary position of the valve by an elongation or contraction of the valve tube, as suspended from the collar under the upper bonnet. The different positions of the handle by means of which the valve tube is rotated, corresponding to the conditions of opening, are indicated on the upper head, by the words "Full," "Half," and "Off."

It will be seen in Fig. 158 that the bonnet chamber does not entirely surround the tube, but that an abutment of about one-quarter of its circumference fits against the tube, so that, when the handle is placed in the position marked "Air" on the upper head, the opening in the side of the valve tube will be closed by this abutment, thus shutting off communication between the interior of the tube and the steam space of the radiator.

Into the lower end of the bottom bonnet enters the pipe which leads to the steam space of the boiler, as in the ordinary one-pipe work; which in this system is preferable, and, as we know, the cheaper. It may, however, be readily constructed on the two-pipe system, if desired.

The operation is as follows: When fire is first started in the boiler and the whole system of pipes and radiators is filled with air, the handle is placed in the position marked "Air," in which case the passage for the discharge of the water of condensation at the bottom is at about half open, and the steam enters through it only, as it cannot enter through the top opening in the valve tube, this opening being closed by the abutment in the upper bonnet chamber. With the pet-cock open, the steam entering at the bottom will expel the air through it. With the air expelled the pet-cock is closed and need not be again opened until the whole system, including the boiler, is allowed to become cold. To run the radiator in full heating effect the handle is placed at "Full," the steam then enters the radiator at the top, through the opening in the side of the valve tube, the valve opening at the bottom serving only for water discharge. This construction obviates one of the greatest objections to one-pipe work, that of having steam entering and water passing out simultaneously at the same horizontal opening whenever any considerable accumulation of water obtains within the apparatus; and this is very often, in most cases.

To graduate the heating effect, the handle is moved into position such that the opening for water discharge will be insufficient to dispose of the amount condensed; in which case the radiator will begin to fill and partially cool off. As it does so, however, the partial cooling of the lower part of the brass valve tube will operate to contract it and thus slightly enlarge the discharge opening beyond what it was set at, and arrest the rise of the water level at some point for any given position of the handle, which will not permit of the full discharge, and thus maintain the water level at some practically fixed point for any position. Conversely, if the radiator has been shut off wholly or partially, and a greater heating effect is desired, the handle is rotated into a position to enlarge the discharge opening, when the falling water level exposes to the heat of the steam a greater length of the brass valve tube causing it to become slightly elongated, and thus slightly close the discharge opening, arrest the falling water level and maintain it at some lower point; and similarly for any position of the handle.

In this way the water level, and consequently the heating effect of the radiator, may be adjusted to be automatically maintained at any desired degree, between being entirely shut off and on in full effect.

With the radiator entirelly filled the level of the water will reach the opening in the side of the valve tube at the top, within the bonnet chamber, and only the small area of this chamber will be exposed to the heat of the steam. Under these conditions the condensation will be exceedingly small, and what steam does condense within the bonnet will finds its way down through the valve tube back to the boiler.

It will be noted that, except in the case of the expulsion of air, the steam has always free access to the interior spaces, either through the valve at the bottom or through the opening in the side of the valve tube at the top, the latter even when shut off from use, or when in partial effect, so that the interior of the brass valve tube is always in communication with the boiler ; and the cracking noise resulting from the admixture of steam and water in the ordinary radiator is entirely avoided, by the steam always having free access to the upper surfaces of the water.

The interior of the valve tube being always filled with steam when the radiator is put out of use, so long as there is any steam pressure in the boiler above the zero point, this tube will be heated ; and this heating of the single central brass tube will be sufficient to slightly warm and, by the circulation it will establish in the surrounding water, prevent freezing ; at the same time it will be so small in amount as to have no perceptible effect in warming an apartment.

Of course, with this apparatus—as with any other, hot water or steam—when the fire is extinguished and the entire system put out of use for the season, the water is drained out of the whole series of pipes and radiators.

It will be seen that in this apparatus all possibility of water leakage at any point is avoided, since there are no valves, stuffing-boxes, or other openings below the highest possible water level ; and even in the extreme case of filling the whole system, through the neglect of an attendant to shut off a high-pressure boiler feed, no other leak can occur than might escape through the single stuffing-box at the top of each radiator if improperly packed. But it is well known that leaks through the stuffing-boxes of the water-discharge valves in the ordinary two-pipe system rarely ever occur, and that it is almost invariably the steam stuffing-box that leaks ; and this, being below the level of accumulated water in the ordinary radiator, gives as great trouble as though it was the water stuffing-box itself. The prolific source of leak, and consequent annoyance and damage in the present steam radiator, is through the air-valve, automatic or otherwise, unless, as some are, they are provided with an elaborate system of small pipes to drain of their drippings to the cellar. The writer has examined and tested a variety of automatic air-valves and has not found one that will not leak water when the radiator is full above the level at which it is attached, or above the level of the opening in the valve for the escape of air. In this system the air-valve is practically dispensed with.

Owing to the lateness of the season at which the writer commenced the preparation of this paper, he has not found time out of his multifarious duties to procure reliable data as to the comparative cost of a radiator constructed on the general plan herein described, and covered in by some sufficiently ornamental grating work, for residences, offices, etc., as he had promised himself to do ; that is, as compared with radiators as now constructed, principally of cast-iron, for either one or two-pipe work. But it will be seen that the first cost of the valve tube and bonnets, if made as cheaply as they may be, will not be very greatly in excess of the system of valves required for two-pipe work ; and certainly not greater than for such forms of the ordinary radiator as, by divided basis and a corresponding plurality of sets of

valve, are intended to subserve something of the purpose for which this is designed, namely, a graduation of the heating effect.

In such a radiator as is shown its effective radiating or air-heating surface will be so much greater for a given space occupied and its weight so much less for a given radiating effect that (taking into account cost of handling and transportation, etc.), without having had time to look closely into it, it is believed that, for an equal heating efficiency, radiators may be produced on this plan as cheaply as any now in use. This conclusion is not, however, at all definite or well settled.

It may perhaps not be amiss to point out that the operation of the apparatus requires no skill for its manipulation or adjustment, and ignorant attendants can hardly make any mistake with it, and certainly cannot do any damage. It may also be noted that the back-aching operation of opening and closing valves situated near the floor is avoided, often most vexatious when stuffing-boxes are packed or screwed up very tight, or a valve has become more or less jammed upon its seat. This feature in the ordinary radiator has been thought to be of sufficient importance to be the subject of a recent patent, which has been quite extensively advertised and illustrated, showing the lady of the house opening or closing the valves with her foot.

It may be mentioned also that in its construction it is not at all necessary that either the valve at the bottom of the valve tube, or the closing of the opening at the top of this tube when expelling the air, should be tight. A slight leakage at the former will only affect the position at which the handle is to be placed for the maintenance of a given water level ; and while expelling the air, so long as the free flow of steam through the opening at the top of the valve tube is pretty well obstructed, the freer entrance of it below will expel the air.

In such cases as when the expense would admit of it, a glass water tube may be attached to one of the outer tubes, by means of which the level of the water in the radiator may always be observed, and thus serve as a guide to the manipulation of the adjustment ; ordinarily, however, feeling of the tubes with the hand will serve as a sufficiently good guide.

The writer has had an experimental apparatus, on the general principles described, in operation in his own residence throughout the winter of 1891–92, and found it to work admirably, giving all needed relief from an overheated room in mild weather, while giving ample warmth when the thermometer ranged low. It also conclusively established its immunity from leakage when, upon a second occasion, the attendant upon the boiler forgot to shut off the boiler feed and filled every radiator in the house with water, this being the only one out of nineteen that was not discharging water pretty freely about the floors from the automatic air-valves, until the surplus water was drawn from the system through the boiler blow-off cock.

HEATING BOILER FEED WATER BY LIVE STEAM.

By Albert Spies, Mem. Am. Soc. Mec. Eng.

WITHIN the past few months several technical journals have published illustrations and descriptions of a system of high-temperature boiler feed-water heating, recently put into marketable shape in the United States, and designed to utilize both live and exhaust steam at the same time, instead of only exhaust steam alone as is usually the case. The system comprises really two heaters. One of these is a small, ordinary ex-

haust steam heater taking the exhaust steam from the engines and pumps of the plant in which the system may be in operation, and by means of it, heating the feed water through what may be considered a preliminary stage, a temperature of from 180 to 190 degrees Fahrenheit being attained. From this heater the water then passes to the second one—the live steam heater—in which live steam from the boiler to be fed, and at full boiler pressure, is the heating agent, and from which, in turn, the water is led into the boiler at a temperature nearly equal to the temperature of the steam and water already in the boiler. The steam which is condensed in producing this result flows to the boiler by gravity. The advantages claimed for the system by the makers of the apparatus are various and important, not the least noteworthy being those of fuel economy and increased steaming capacity of the boiler to which it is applied.

The conclusion, however, to which a great many engineers will probably jump at once is that the live steam heater part of the outfit is of little, if indeed any, use, since through it simply a certain quantity of heat is taken away from the boiler, transmitted to the feed water, and is, finally, again returned to the boiler, so that the whole operation would seem very much like taking money from one pocket of one's clothes and putting it back into another, or like "Robbing Peter to pay Paul," as it has been put. It is a simple transfer, some will say, and there is no reason why anything should be gained by the method. Indeed, if anything, there ought to be a loss of heat by radiation from the pipe connections and the heater surface itself. But, as a matter of fact, this use of live steam does actually represent a saving, however startling and contradictory it may appear, and the case seems to have been pretty definitely settled in England several years ago by Kirkaldy, to whose experiments it may, therefore, be of interest to refer at this time.

From what data there is available bearing on the subject, it appears that, briefly speaking, Kirkaldy took steam direct from a boiler to heat the feed water and, strangely enough, secured an economy of something like seven per cent. Incredible though this statement appeared at the time, and unexpected as the result was, its correctness was borne out by the reports of a number of other engineers who tried the experiment. It is proper to say here, as was remarked in some of the foreign journals at the time, The London Engineer among others, that when Kirkaldy first proposed to use live steam in this way, he had no idea of securing a saving of fuel by the method. He simply thought that it would be a good thing in the case of freight steamers, usually pressed for time, if their boilers, after being emptied in port, were filled up with hot water instead of cold. To this end he arranged apparatus by which a donkey boiler could supply steam to heat the cold feed water before it was pumped into the main boilers. This worked very well, and he extended his operations so that the feed could always go in hot, not to save fuel, but to prevent the injurious strains which cold feed water is likely to set up in a boiler. He argued, of course, as others would have argued, that the steam could give up no more heat to the feed water than it withdrew from the boiler, and that, as a matter of course, there would be no economy. It turned out, however, that the boilers to which the arrangement was fitted steamed better and held their pressure more steadily than before; and later, the results of careful trials left little doubt that the Kirkaldy heater did effect a very considerable saving in fuel.

The result, it was thought, was due in some yet-to-be-explained way to an increased efficiency of the heating surface of the boiler, probably owing to better circulation. Of course, as already stated, as nothing can be taken out of the boiler that has not first been put into it, no direct economy can result from the use of steam drawn from the boiler to heat the feed water. Secondary influences, however, are at

work, and to these the economy effected is, no doubt, due.

A somewhat similar system of heating feed water, which led to similar conclusions and results, has been in use for some years on an English line of steamers and is said to have given great satisfaction. It is known as Weir's system. Steam is drawn from the intermediate receiver of the compound engines and is blown into the feed water, the temperature of which is thus raised very nearly to that of the steam in the receiver, say about 250 degrees. The practical result was stated to be a saving of about eight per cent. effected by raising the feed temperature, and it was shown that about four per cent. was lost by the withdrawal of steam from the receiver, which would otherwise have gone to increase the work done in the low-pressure cylinder, thus leaving a net saving of four per cent. There appeared to be no doubt whatever that this astonishing result was obtained.

SUCTION WATER UNDER PRESSURE FOR PUMPS.

By R. Van A. Norris, Mem. Am. Soc. Mec. Eng.

THE following experiments were made in April, 1892, with the view of determining the advantages of the plan of feeding water under pressure to a direct-acting pump over that of drawing the water from a receiving well. The circumstances were as follows :

The borough of Nanticoke, Pa., is supplied with water from Harvey's

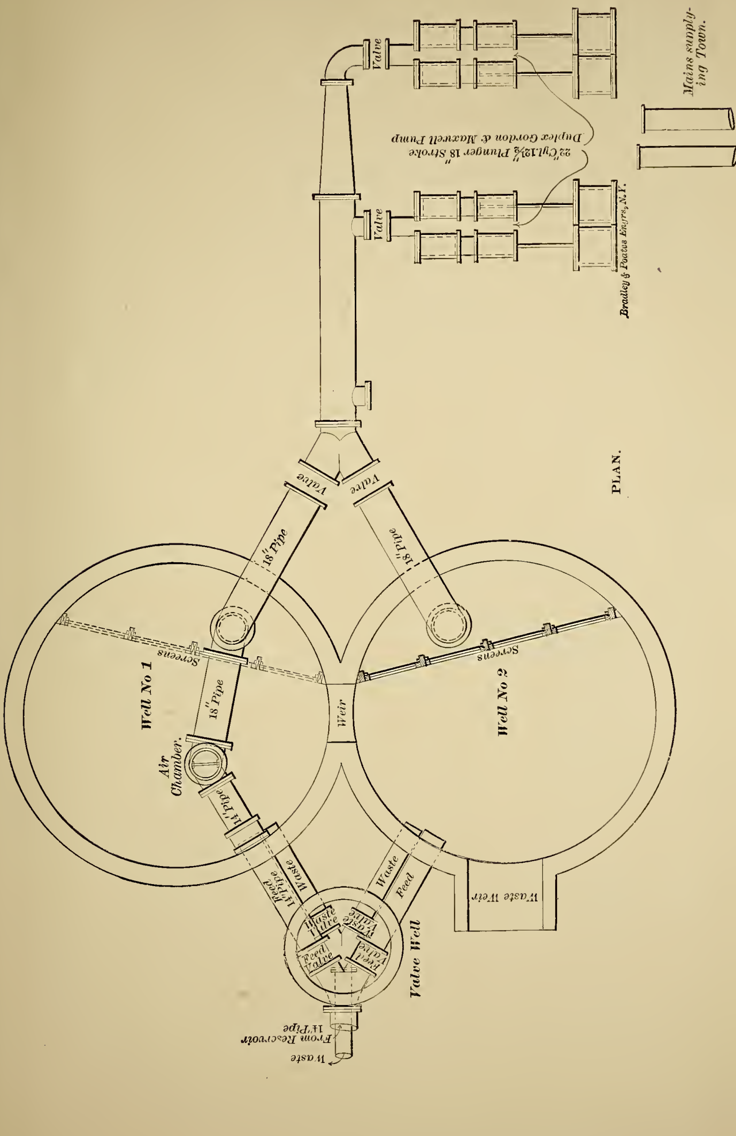
TESTS OF NANTICOKE WATER CO.'S PUMPS, APRIL 9, 1892.

PUMPING FROM WELLS AND DIRECT FROM SUPPLY MAIN.

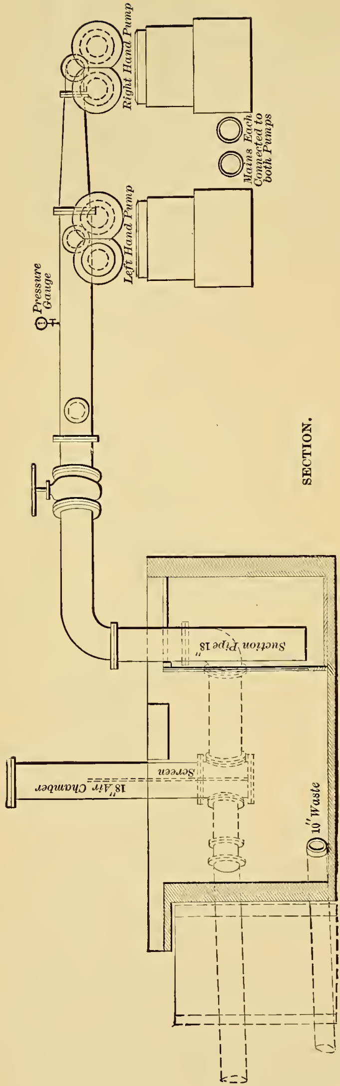
TESTED BY J. H. BOWDEN AND R VAN A. NORRIS.

Gordon and Maxwell Duplex Plunger Pumps. 22-Inch Steam. 13½-Inch Plungers. 16½-Inch Stroke.	Condition of Working.	Single Strokes Each Plunger per Min.	Average Mean Effec. Pressure, Steam.	Average Steam Consumed Per Hour.	Average Pumping Pressure Above Atmos., Lbs.	Average Pressure in Tail Pipe, Lbs.	Average Back Pressure on Plunger, Lbs.	Per Cent. Pressure in Tail Pipe Utilized.
Right-hand pump...	Suction.....	50	36.1 lbs.	3,156 lbs.	93.5	—3·$\frac{1}{10}$		.....
	Pressure....	50	24.75 lbs.	2,420 lbs.	99.6	+30	25$\frac{3}{10}$	85$\frac{1}{10}$%
	Difference..	..	11.35 lbs.	736 lbs.	....	......	....	.....
		..	31$\frac{5}{10}$%	23$\frac{3}{10}$%	....	......	....	.....
	Suction....	25	33. 4 lbs.	1,358 lbs.	91.9	—3·$\frac{2}{10}$	....	.....
	Pressure....	25	23. 1 lbs.	1,060 lbs.	97.3	+32	29$\frac{4}{10}$	91%
	Difference..	..	10. 3 lbs.	298 lbs.	....	......	....	.....
		..	30$\frac{8}{10}$%	21$\frac{9}{10}$%	....	......	....	.....
Left-hand pump....	Suction.....	50	33. 9 lbs.	2,912 lbs.	....	......	....	.....
	Pressure....	50	25.25 lbs.	2,369 lbs.	....	......	....	.....
	Difference..	..	8.65 lbs.	543 lbs.	....	......	....	.....
		..	25$\frac{5}{10}$%	18$\frac{6}{10}$%	....	......	....	.....
	Suction.....	25	32. 4 lbs.	1,314 lbs.	....	......	....	.....
	Pressure....	25	23. 3 lbs.	1,060 lbs.	....	......	....	.....
	Difference..	..	9. 1 lbs.	254 lbs.	....	......	....	.....
		..	28$\frac{1}{10}$%	19$\frac{3}{10}$%	....	......	....	.....

* Paper read before American Society of Mechanical Engineers.



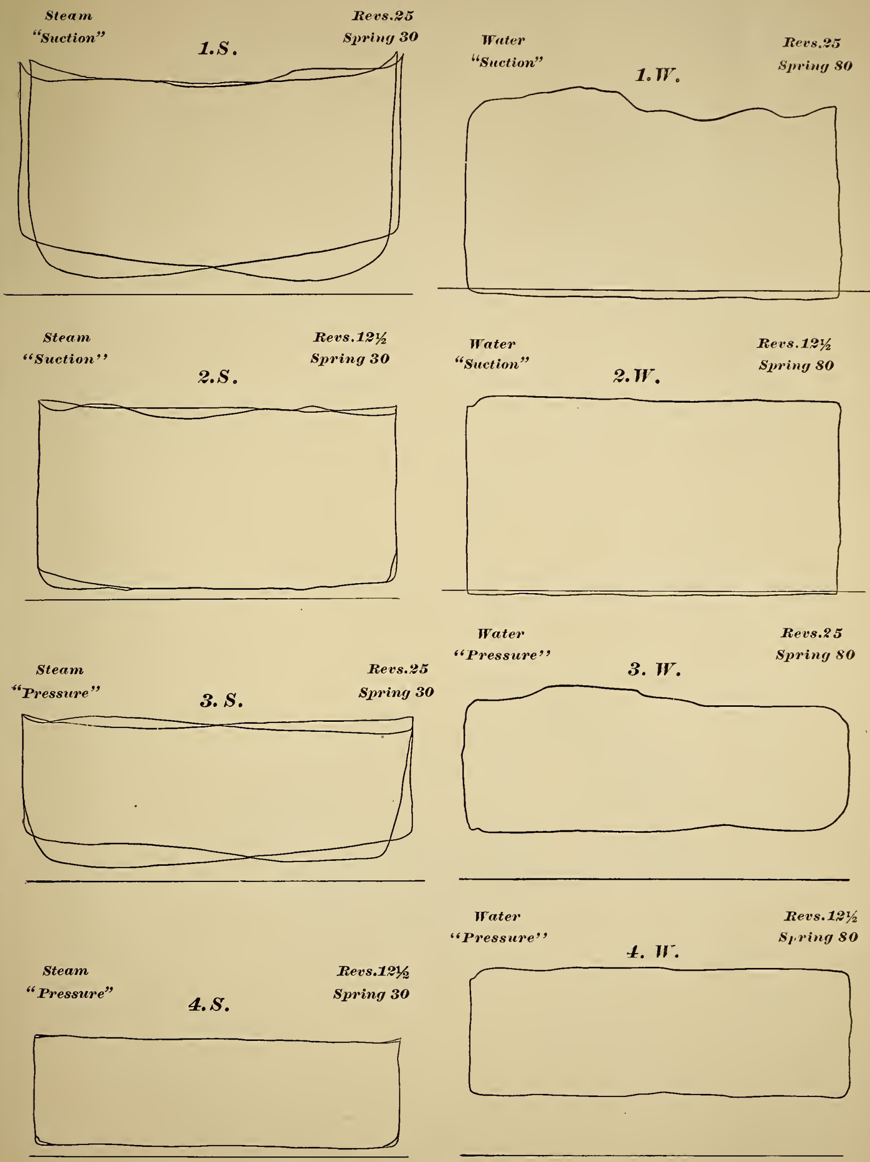
PLAN OF PUMPING STATION.



Creek, a small stream tributary to the Susquehanna, the water being conducted through mains from a dam some two miles up the creek, and reaching the Nanticoke Water Company's pumping station with a piezometric head of about sixty feet when the pipe is flowing about 1,000,000 gallons per day. Up to the above date the water had been discharged at the pumping station into two receiving wells (Fig. 55), and thence pumped into the town mains by two duplex Gordon & Maxwell pumps, twenty-two inch steam cylinders, twelve and one-half inch plungers, sixteen and one-half inches actual stroke. It was suggested by Mr. J. H. Bowden, the chief engineer of the company, that the pressure of water in the mains could advantageously be used in feeding the pumps. Accordingly one well was thrown out of use, and the connection shown in Fig. 55 put in, consisting merely of an eighteen inch pipe connecting the suction of the pumps to the inlet from the main and extending across the No. 1 well, with a ten-foot length of eighteen inch pipe standing vertically as an air chamber, to obviate any danger to the pumps from water ram. In this air chamber, and extending to the bottom of the tee to which it was connected, was a movable screen for removing any floating material from the water. This screen is readily removed from the bottom for cleaning.

Both pumps, it will be seen, were arranged to draw from either well, so that no stoppage was necessary in making the change; and when it was desired to change from suction to pressure, or *vice versa*, all that was required was the opening of one valve and the closing of another.

The pumps are supplied with steam from the Susquehanna Coal Company's boilers at their No. 2 shaft, distance about 150 feet, through a six-inch wrought pipe, and just before the pressure was turned on they were both making twenty-five single strokes of each plunger per minute, sucking their water from No. 2 well. As soon as the valves were changed their speed increased to thirty-three strokes, without change o



INDICATOR CARDS FROM STEAM AND WATER CYLINDERS.

steam valves, and they appeared to run much more smoothly.

The accompanying indicator cards were taken on April 9th by Mr. Bowden and the writer, and the results in following table calculated from them. Four cards were taken from each end of each cylinder under each condition, and the results in the table are averages from them. The pressure in the "suction" pipe was determined by a pressure gauge in the position shown, read at time of taking each card. Cards were taken under the following conditions :

Suction from well, fifty strokes of each plunger, cards 1 *S.* and 1 *W.*

Suction from well, twenty-five strokes of each plunger, cards 2 *S.* and 2 *W.*

Pressure from main, fifty strokes of each plunger, cards 3 *S.* and 3 *W.*

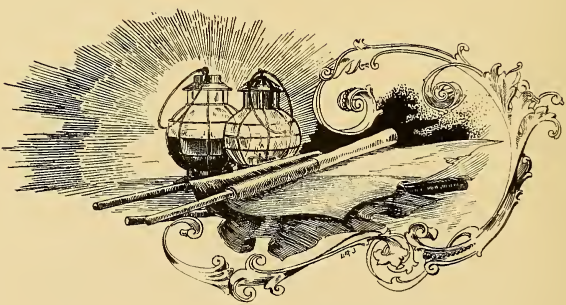
Pressure from main, twenty-five strokes of each plunger, cards 4 *S* and 4 *W.*

They seem to show that about ninety per cent of the gauge pressure in the main was utilized, and that the resulting saving in steam calculated from the cards was about twenty per cent.

No measurement of the water pumped under the two conditions was attempted, as it went directly into the supply pipes ; but the pumps appeared to work more smoothly and to keep the stand-pipe level more constant under pressure than when sucking.

The suction valves of the pumps were provided some years ago with springs to make them seat promptly, and these were not altered by the change in method of feed.

These experiments were made simply for our own satisfaction, and, while not carried far enough to be of exact quantitative value, it is hoped that they will be of some interest, sufficient to elicit discussion.



THE PRESENT STATUS OF ENGINEERS.*

By H. F. J. Porter.

PROFESSIONS are fostered by the manner in which they meet the demands put upon them, but unless their growth is guided by far-seeing minds devoted to their interests, they will split in lines which will cross and interfere with each other, and prevent the normal and perfect development of their various divisions. Now the engineering profession has, from the sudden nature of the demands for development in new directions, been unable to systematize itself, and is not yet old enough to have asserted a system by its own weight. The professions of medicine and law are older and comparatively well in hand. The duties of each member are well defined; they are those of a specialist. Professional etiquette forbids their encroaching on each other's province. The standing of these professions is maintained by the legal requirement of a license or its equivalent before practice is allowed.

Although there have been in all ages men whose qualifications entitled them to be called engineers, our profession, as such, is comparatively young. The steam engine, which has made it what it is, was perfected only a little over a century ago. The term "engineer" was unknown with other than a military signification until the present century. Engineering scarcely ranked as a profession until there were schools to teach it, and there were none such in this or any other English-speaking country prior to 1840. Let us examine its history, and note the sources from which it has drawn its men.

Its development both in this country and abroad has been on similar lines, though in the latter it was at first more rapid. Inventive genius was as quick to mature here, but the country was too new and the amount of available capital too small to foster it. As the country opened up and became more settled, the demand for professional men became apparent. Manufacturing interests sprang into existence, and facilities for transportation became necessary. The first engineering work of note requiring professional skill was the Erie Canal in 1817, and following this came an era of canal building, bringing many able men into prominence, and lasting possibly up to 1840. Railroad building began in 1830, and by 1840 there had developed a strong demand for engineers. Now up to this date there were but two methods of obtaining preliminary training for the profession; the first by entering as a "student" in an engineer's office or as an "apprentice" in a shop; the other by graduating at the West Point Military Academy. The supply of professional men from the polytechnic schools of France and Germany was not felt, and, with the exception of a few from West Point, the field was filled with men who were self-taught geniuses. The demand for a higher grade of engineer was responded to only in 1840, when the Rensselaer Polytechnic Institute, at Troy, N. Y., opened its doors and began to turn out "civil" engineers. This term had recently been coined to distinguish those engaged in general practice from "military" engineers, whose paths lay in the direction of warfare. For twenty years this school alone supplied technically educated men to the country. Other schools of engineering were founded, yet it was not until 1860, that students began to graduate from the engineering departments of Dartmouth, Union, Harvard, and Yale Colleges, and Michigan University. It is evident that the demand must have far exceeded the

*Paper read before the American Society of Mechanical Engineers.

supply, and that the ranks were still recruited from the large body of practical men who thus had a motive offered to stimulate their ambition. The technical courses compared with those of the present day were very crude. Experiments had not been made, data had not been collected from which very advanced theory could be drawn. Although the Government lent its aid at last, and the Agricultural College Land Grant bill of July 2, 1862, gave a new incentive to the establishment of institutions of this character, still the war held it in check, and it was not until the country had settled down again that we find technically educated engineers supplied in any great numbers.

During all this time the country had developed with wonderful rapidity. Industries of all kinds were thriving, and competition was creating a demand for men with more of a mechanical bent to their training than was given in the civil engineering course. The mineral wealth of the country had become apparent, and the need of men educated in chemistry and metallurgy was being felt. The course of instruction in the schools had broadened to comprehend this widening field, but the man who at this time was supposed to be able to solve any and every known engineering problem was a "civil engineer."

But the work was becoming so diverse in character that no one man could devote to it the time necessary to learn it all. The civil engineering course became too ponderous and broke under its own weight, and between 1866 and 1872 we find a Polytechnic School in Brooklyn, and one in Philadelphia, an Institute of Technology at Boston, and one at Hoboken, and a department of Cornell University, turning out "mechanical" engineers, while the Shool of Mines of Columbia and Lafayette Colleges and Lehigh University produced "mining engineers." Still later, when iron and steel began to be supplied for structural purposes, the profession of the architect became merged with that of the engineer, and courses in architecture began to develop; and, still more recently, discoveries in electricity produced schools of electrical engineering.

Thus have the schools followed the growth of the profession and endeavored to supply the demands for the increasing number of specialists. It is evident that schools cannot start their course of instruction in a specialty until the direction and details of its practice have been pretty well developed, and during this time its ranks become filled by pioneers, many of whom rise to eminence, although they may not be technically educated. Even in the older branches there is nothing to prevent the self-taught surveyor or mechanic not only from forging to the front, but from assuming the scholastic title or degree which his neighbor has devoted years to obtain with a considerable expenditure of money.

There are great differences in the methods which the schools themselves adopt for training students to obtain these degrees, and this absence of harmony has hurt the profession not a little. Courses vary in length all the way from three to six years, and the title given at graduation varies to such an extent that it may mean anything or nothing. At one school, before obtaining the degree of C.E., M.E., etc., a man must devote four years to theory, and afterward a year and a half or two years to practical work; in another, only four years of theory and practice are necessary; while, at still another, three years of theory pure and simple will give the same degree.

What respect can the public have for a profession which is prepared for so variously and which does not attempt to exclude a class of men who may even assert a right to practice on their own assumed qualifications? Regarding these two classes, I have just a word to say, that I may not be misunderstood. Some of the best engineering work of the country has been accomplished by men who had no technical education as such, and some of the worst has been accomplished by graduates from engineering schools. The result is what we might expect. The title conferred by an engineering school

does not inform the public in the slightest degree as to the qualifications of the recipient to perform work. A man makes his reputation in the world by the general characteristics of his make-up and by the opportunities which he seizes. The standing of the profession, however, is affected when its *personnel* is heterogeneous. It is here that the general public loses confidence in us, for it thinks that we should have some jurisdiction over such matters.

There is no standard by which an engineer may be judged. John Smith, M.E., may be a most able theoretical and practical engineer, technically educated, with a most varied and thorough practical experience added; or, on the contrary, he may be a discharged mechanic who cannot hold a position, who has opened an office and placed his name on the door, with the title added on his own responsibility.

There are those who hold that there is a difference between the title "C.E." and the name "civil engineer"—that the former is purely and distinctly a degree, conferred by a technical school, and becomes as much part of the name of the holder as his Christian name which was conferred on him at baptism, while the latter may be acquired in various other ways, and should be considered only with reference to the manner of its acquirement.

John Smith, C.E.,

they say, means that the man has at least some technical education; how much is not known; it depends upon the school from which he graduated. As to practical experience, one must ascertain his age and somewhat of his history. But

John Smith,
Civil Engineer,

means that he has (or should have) held the position of that title in some railroad or similar corporation, and continues to bear it by merit. When a man presents his card introducing himself as

John Smith,
Civil Engineer,
X. Y. & Z. R.R. Co.

there is no doubt at all as to his pretensions, provided the X.Y. & Z. R.R. Co. is known; but without the limitation where somebody assumes responsibility for giving him the title, there is at present a great uncertainty as to its meaning, and necessarily it is losing its force, and the profession is consequently affected.

It is, however, mostly through the work of the incompetent that the profession is injured. There is no other which assumes as great responsibilities over life and property as does ours. Mammoth office buildings, holding within them an aggregation of thousands of people; ocean steamers of almost as great capacity; railroads of various motive powers, carrying their living freight at terrific rates of speed; dams and dikes which make possible the existence of communities — all threaten frightful disaster and wholesale destruction through the incompetence of either the designer, the superintendent of construction, or the director of maintenance. No other profession can be taxed with such responsibility or claim less careful preparation for assuming it.

Are we not neglecting our duty toward the public by remaining passive in the face of this situation? Are we not assuming the responsibility for this condition of affairs when, understanding it, we make no effort to apply a remedy?

It will be said at once that the proper consideration of a subject of this character is no light task; that it should be participated in by men representing all branches of the profession at a regularly convened congress. It will also seem to be necessary to have a standing committee appointed to prepare the work properly for presentation to such a congress, and afterward carry out such instructions as might be given by it.

The convening of a congress for this or any purpose is a vast undertaking, and the support of a committee composed of representative members of the different branches of engineering is, under ordinary circumstances, almost impossible to obtain.

The practical impossibility of making the necessary preliminary arrangements might be a plausible excuse for not undertaking such a work.

But just such a congress as this has already been called to meet in August next, at the World's Columbian Exposition at Chicago, and a more representative and able committee of engineers could not have been appointed than now has in charge the work of arranging for the details of its sessions.

The Exposition, through its Congress Auxiliary, has already projected the most perfect arrangements for the gathering together of great minds to consider every question which will interest humanity. Not only will the engineer be there, but the educator will be on the same platform, and will be expected to confer with him on questions of mutual interest.

It will be a very long time before such an opportunity as is now presented will again be offered for the consideration of this question in all its aspects.

The committee I have mentioned represents the best engineering societies of all kinds in the United States and Canada. It can formulate this subject and bring it up at the right time.

After the congress has adjourned, the committee, with its strong executive board, could be made perpetual in its nature though changing in its personality. Its duties might be those of a Board of Regents embodied with power to confer titles for merit. Such a board, composed of practical men of the world, would be capable of judging what a man should know in order to bear a title. It should endeavor to bring about a unity of method among the schools as to the education of the engineer, so that a degree given on graduation would mean just what it says, and subsequently, after a term of practice, and after passing an examination, a title could be conferred by the board or its authorized representatives in each State, practically licensing the recipient to practice. Nor would it be necessary to attend a technical school to obtain a title ; the self-taught genius, on proving himself capable, would be awarded one as well.

The task of such a reconstruction and reorganization is a difficult one, but would become less so every year. Boards of Education already meet to discuss such subjects. Pedagogues are reducing their art to a science, and inviting to their symposiums of learning practical men to aid them in the accomplishment of their undertakings.

A properly authorized committee has thus within its reach the power to accomplish a work which is far-reaching in its results, and which would fully repay it for its labors.

Let us consider for a moment the present field of engineering.

That it is unevenly divided goes without saying. Originally all was "civil" in contradistinction to "military," but still the name continues, though the practice has changed, and it follows that this branch is now misnamed. I have in my possession a list of works issued by a well-known publishing house on various branches of engineering. In this list I find books on engineering of the following kinds, many of which are very closely allied. They are railroad, highway, field, sanitary, water supply, hydraulic, municipal farm, mechanical, mill, gas, steam, heating and ventilating, mine, bridge, marine, water, naval, maritime. In all of these mechanical engineering plays a dominant part. Electrical engineering, the latest development, is said to be "engineering, one-eighth of which is electrical and seven-eighths mechanical," and some schools refuse to recognize it as a branch, merely adding electrical instruction to the course in mechanical engineering. It is claimed that in this way a better fitted man is evolved than the graduate of the electrical engineering course, who is more essentially an electrician.

Of late the architect has been drawn rather unwillingly into closer contact with the engineer. The real architect of the present is essentially an engineer, and the number of real architects is rapidly increasing, owing to the influence of the schools. But the man

who has a good idea of proportion, combined with a knowledge of history and a fair amount or taste and originality in design, with a quick eye for observation, can, with the services of a contractor and builder, become a very good so-called architect. The existence of these two types of men has done much to prevent architecture from assuming its proper place in engineering. The ordinary architect of the present day holds a very lucrative and respected position, while the engineer who does his work, and for which he gets no credit, is a poorly paid subordinate at the draughting board. It is difficult to determine what field the consulting engineer and the mechanical expert do not cover. It would require more space than I consider to be necessary for the purpose, to dwell upon them here, and they will receive no further comment.

Surely an active committee could not find itself better employed than in establishing a more perfect balance between these different branches of the profession. The tendency of the times is toward specialities, and if the different divisions could be revised in that direction, not only would the preliminary education of each be more perfect and well directed, but the subsequent practice would be more thorough, and the consequent results more remunerative. If each individual, after his final license is issued, should be compelled to continue in the lines laid down for him there would be no encroachment on the practice of engineers educated in other branches, and professional etiquette among the members of the profession would not be a dead letter, as it is to-day.

For the sake of illustration, let us suppose that students should receive at all engineering schools alike a three years' course in the elements of general engineering, obtaining a degree of Bachelor of Engineering or its equivalent. Subsequently they should be required to perform practical work under the guidance of the school, in lines laid down by the committee, for two years, to fit themselves for examination and license by the committee for one of the special divisions of engineering. They would receive the same education as before, but their standing before the community would be known, and they would fit more perfectly the niche which was cut out for them.

Let us suppose the professional field to be redivided on a more rational basis than the present, so that the student could make his selection more deliberately and prepare for the future with a knowledge of the discriminating scope of his practice. Grouping together similar kinds of work would allow the practitioner to devote himself to a specialty, and he could then successfully cover its literature and keep pace with its development.

The following division is possibly more theoretical than practical, but is offered merely as a suggestion in this direction :

I. Mining Engineering, including the locating, prospecting, and working of mines of all kinds, and, in general, obtaining the raw materials of the trades from the earth.

II. Metallurgical Engineering : the conversion, by the blast furnace, smelting oven, or other similar method, of the raw materials into the finished merchant bar, etc.

III. Manufacturing Engineering : general manufacturing, with a knowledge of international, commercial, and patent law, political economy, methods of obtaining cost of product, making duplicate pieces, etc.

IV. Static Engineering : erection of iron, steel, and stone buildings, lighthouses, bridges, ships, etc., with a knowledge of the strength of materials to resist static stresses.

V. Dynamic Engineering : designing and building of generators and prime motors, and assembling them into power plants ; machinery and mill work ; transmission of power ; development of power by steam, air, gas, electricity, and water, with a knowledge of the kinematics of machinery, heating, ventilation, etc.

VI. Land Engineering : construction

of railroads, street railways, highways, laying out of cities, surveying and grading, farm engineering, tunneling, etc.

VII. Hydraulic Engineering: construction of canals, docks, dams; laying out of harbors; water-works, sewage, drainage, fire protection, plumbing, etc.

VIII. Aerial Engineering: aerial navigation by balloons and flying machines; weather bureau, etc.

IX. Military Engineering: fortification, artillery, torpedo service, gunnery, and engineering as applied to warfare.

These lines should be strongly drawn, and the province and duties of the engineer in each division should be well defined. It would not be necessary that a man should practice in only one of these, provided he could obtain a license to direct his work in another. When it became known, however, that a testimonial of efficiency in each of the above directions was required, the public would place more confidence in our work, and would know more readily where orders could be properly placed. The large body of licensed specialists would be able to obtain a living on the standard fees required for their work, and the underpaid engineer would become a being of the past. The incompetent could not thrive, while there would be a good living for all who survived the final test. Regular fees should be agreed upon for specifications, designs, drawings, superintendence, etc., varying according to the type of work considered. Standards should be adopted as to sizes, weights, shapes, gauges, methods of testing, etc. Legislation should be promoted or opposed with the full strength of the profession, accordingly as its interests were to be affected by the proposed measure. As the whole field of labor would be practically in charge of an engineer in one or another of the above divisions, the profession, as the connecting link between the interests of capital and labor, could with judicious management become the arbiter in this most momentous question of the day, and a most important factor in its settlement. These various duties should properly belong to such a standing committee as I have pointed out, and I have little doubt that many others would also be imposed upon it, although its hands would be full with those enumerated.

That the work here outlined could be accomplished so as to bring about immediate results, I do not claim would be practicable or even possible. Years would elapse before the consummation of such a revision. Yet I do believe that the adoption of some such plan would have a most salutary effect upon the profession in the immediate future, and that when the next Columbian Exposition, like this one made possible by the progress in mechanic arts due to engineering, will compare the standing of the profession then with what it is now, the individual members will see the wisdom of our deliberations in the advanced position which engineering will have then attained.

If I have made it evident that our situation is not what it ought to be, that it has come to where it is from natural causes and from the lack of proper regulation and guidance, my desultory remarks will not have been in vain. I know that if I am right in my premises, there can be no better opportunity than is offered by the approaching congress for devising a remedy and setting in motion the machinery for enforcing it. When there are a known cause for complaint, a known remedy, and a means for its application, I think there can be little doubt that circumstances will bring them together. If my suggestions are too utopian, it will matter little; they are offered to induce discussion simply. I only hope that it is possible to draw from my remarks a cogent reason for the presentation of this topical query at this time, for I have tried to impress upon you that just now there is a tide in our affairs which, taken at its flood, will lead to a consummation devoutly to be wished.